

Technical Reference Handbook

Version 2.4 – 2022-07-17



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⁷<mailto:jfk@marktyler.org>

Preface

This document outlines my animation “**Motorcade 63**”⁸. The intended audience is those interested in researching the assassination of John F. Kennedy who want to understand more fully what I have created, how I went about building it, and why I was motivated to start this project. Due to the technical nature of this work readers are expected to have extensive experience with assassination research.

As with all of my published work⁹ I welcome feedback from people who want to make a constructive contribution, whether that be to correct small nitpicking errors (e.g. spelling mistakes), or larger technical and philosophical criticisms. Please send me an email¹⁰ if you wish to share your thoughts, or if you have any queries.

If you are reading this online (and your viewing software allows it), click on a blue hyperlink to jump to that section in the document or to open the web link.

This document has been written mostly using UK English, which occasionally varies from US English, e.g. kerb versus curb. Quotations from other sources are copied verbatim using notation “*like this*” in italics and cited with reference to a numerical footnote. Date formats are kept to the ISO 8601¹¹ standard, i.e. YEAR-MONTH-DAY (e.g. 1963-11-22).

⁸<https://www.marktyler.org/mc63.html>

⁹<https://www.marktyler.org>

¹⁰<mailto:jfk@marktyler.org>

¹¹https://en.wikipedia.org/wiki/ISO_8601

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Part I

Introduction

Motorcade 63 is an animated reconstruction of the events surrounding the assassination of John F. Kennedy. It is based on photos, films, and corroborated witness testimony with the aim of being as faithful as possible to the facts. It covers the time period from the first pilot car turning onto Houston Street to when the rear Dallas Police car leaves Dealey Plaza under the triple underpass bridge.

The animation is a mathematical model with fixed points on a timeline which depicts the known positions of the people and vehicles from the photos and films. A computer program then calculates how these actors move between the known positions in a smooth and plausible fashion.

After the completion of the animation I was then able to review the witness testimony and come to a more informed judgement about events due to the synchronization of the evidence. Hopefully other researchers will find it as useful as I do in understanding the events that unfolded in Dealey Plaza in 1963.

1 Jargon

Here is a table of acronyms and other jargon that I use many times in this document.

Table 1: Acronyms and other Jargon

Abbreviation	Description
FPS	Frames Per Second.
HSCA	House Select Committee on Assassinations.
JFK	John F. Kennedy.
Mc63	Motorcade 63.
MPH	Miles Per Hour.
TSBD	Texas School Book Depository.
V.x p.Y	Citation: Volume x Page Y.
WCR	Warren Commission Report.
WCR CE	Warren Commission Report Commission Exhibit.
Z133 - Z486	Zapruder film frame numbers.

2 Project Genesis

As 2019 began, I realised that I had been reading books and watching TV documentaries about the JFK assassination for over thirty years, and yet some of what happened in Dealey Plaza in 1963 seemed unexplained or ambiguous. A lot of the material I had consumed was extremely unpersuasive due to authors cherry-picking weak evidence and ignoring stronger contrary evidence.

Even the official investigations, while extensive and mostly credible, seemed to have rather unpersuasive or disappointing elements to them. For example the Warren Commission made no attempt to nail down what happened to the missed shot during the assassination, which rather dented my confidence in their final conclusions regarding the Dealey Plaza crime scene.

I started to wonder how I might investigate the events by using my various analytical skills and a more open ended approach. I decided to sift out all of the facts so I could see what picture would be formed by only using photographs, films, and corroborated eyewitness statements. A good example of this was regarding the position of officer H.B. McLain during and after the assassination. The HSCA made very specific claims about the position of his motorbike due to the sounds recorded on a dictabelt¹² during the assassination, so I thought it would be useful to either prove or disprove this work.

With no photos or films to prove or disprove the HSCA directly, I tried to fill in this gap in the evidence by using indirect evidence: synchronicity¹³ and deductive logic¹⁴.

With hundreds of eyewitnesses, dozens of photos, and several films, I decided a simple animated reconstruction would be a good way to

¹²https://en.wikipedia.org/wiki/John_F._Kennedy_assassination_Dictabelt_recording

¹³[https://en.wikipedia.org/wiki/Synchronicity_\(disambiguation\)](https://en.wikipedia.org/wiki/Synchronicity_(disambiguation))

¹⁴https://en.wikipedia.org/wiki/Deductive_reasoning

understand in real time what happened that day in Dallas, and test some of the theories regarding this case.

I wanted this animation to be a 2D map view so it would be easy to cross examine using straight lines to check trajectories and lines of sight. In a 3D model, due to perspective and other problems, the viewer cannot meaningfully check the veracity of the work. I want to engage others with Mc63 by allowing them to check their own ideas, and enable them to suggest improvements to Mc63 if they spot any errors or have ideas for improvements.

I have seen others succumb to many fallacies in this case, so I wanted to avoid such problems in my work. One example would be the “*Argument from authority*”¹⁵ fallacy, such as during “*CBS News Inquiry - The Warren Report*”¹⁶ when Luis Alvarez¹⁷ was used to add weight to some otherwise implausible theories (e.g. to suggest a single gunman could aim and fire two shots from a bolt action rifle in less than 2.5 seconds). We should judge theories on their basis in fact, not on the curriculum vitae of the person proposing them.

I also wanted to avoid the common mistake of obsessing over the Zapruder film. While the Zapruder film is a hugely useful piece of evidence, on its own it only directly proves when one of the three (or more) shots was fired. Serious researchers will need to look elsewhere for evidence of the other shots fired that day. This over-analysis of the Zapruder film creates red herrings such as assuming a shot was fired because someone turns their head after a few blurry frames. If these observations of the Zapruder film really were evidence of a shot then dozens of shots were fired that day (a view which none of the witnesses support).

¹⁵https://en.wikipedia.org/wiki/Argument_from_authority

¹⁶Part 1, time 38:15 <https://www.c-span.org/video/?453991-2/a-cbs-news-inquiry-warren-report-part-1>

¹⁷https://en.wikipedia.org/wiki/Luis_Walter_Alvarez

Part II

Motorcade 63

3 The Abstract Model

Mc63 is a 2D map view model of the Dealey Plaza crime scene, with overlays to depict the motorcade vehicles and other interesting actors. It is designed to be a useful research tool for checking theories using lines of sight, bullet trajectories, and timings. The rules of the animation are set in a computer program with the coordinates in a database so I can easily modify the model by adjusting the measured positions and timings.

3.1 Geometry

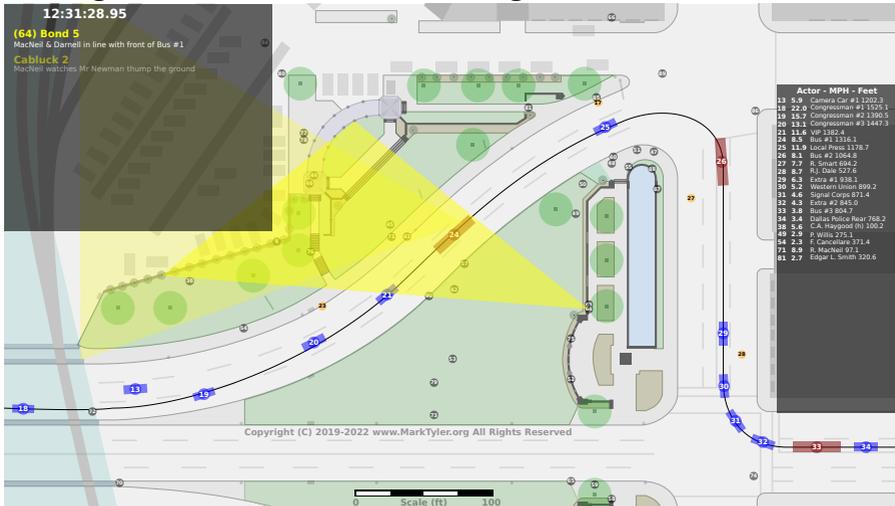
I have used cubic Bézier curves¹⁸ to model the movements of the actors on the map. These curves operate like tramlines with the actors moving smoothly along them as they pass through Dealey Plaza. For example we could look at Congressman Car #1 and verify its position using photos and films:

- The Hughes film shows it turning onto Houston Street from Main Street.
- The Dorman film shows it approaching the turn from Houston Street to Elm Street.
- The Cancellare 2 photo shows the front of it halfway down Elm Street.
- The Paschall film shows it leaving under the bridge as it passes Camera Car #1.

These observations allow me to construct a curve which correlates to these movements, and then overlay this curve on the map to check the results like this:

¹⁸https://en.wikipedia.org/wiki/B%C3%A9zier_curve

Figure 1: Animation Frame “Congressman Car #1 Route”



3.2 Time

I judge time by using the films taken on the day. We can't ever know the exact times due to the primitive nature of the film cameras used (see section 3.5.3 and appendix C.1), however we can know the approximate timings involved. Even when we only have still photos we can still work out what speeds people are moving at due to them either running or walking (e.g. walking means 2-4 MPH, running 5-15 MPH). Here are some running examples that can be verified:

- James Altgens said he “*ran fast down across the Dealey Plaza*”¹⁹. Mc63 suggests this was 11-13 MPH.
- Phil Willis ran 12-15 MPH as he went from Houston Street to Elm Street, according to Mc63.
- David Wiegman ran 11-12 MPH down Elm Street, and towards Beatrice and Charles Hester, according to Mc63.

¹⁹WCR V.7 p.517 https://www.history-matters.com/archive/jfk/wc/wcvol5/wh7/pdf/WH7_Altgens.pdf

- C.A. Haygood and Robert MacNeil²⁰ ran up the grassy knoll reaching a peak speed of around 7-8 MPH. Due to the grassy incline they did not run quite as fast as others elsewhere on a flatter and firmer surface (it had been raining that morning so that area of the knoll was probably a little soft²¹).

These speeds all seem about right to me. If a photo or film showed someone running, but Mc63 only showed them moving at 2-3 MPH then this would be too slow. Likewise 20-30 MPH would be too fast. We can never be 100% certain of exact speeds, but they do need to be plausible for Mc63 to be close to what really happened in 1963.

3.3 Inbetweening

Once actors have been fixed in space and time for particular key points, I get the computer to calculate mathematically where the actors need to be when rendering each animation frame. This process is called inbetweening²². In order to do this smoothly I have used Bézier curves in space and time so the actors move, accelerate and decelerate in a plausible fashion. In addition, I have tilted the cars and buses to the line of the curve so they move realistically around bends in the road.

3.4 Synchronicity

At the heart of any reconstruction of the Dealey Plaza scene is an understanding of how events unfolded. Some of these events were captured on films and photos so we can see them clearly (e.g. positions of cars and people). Others however were not captured and we can only speculate about what happened.

²⁰https://en.wikipedia.org/wiki/Robert_MacNeil

²¹Sam Holland - "Well, you know it'd been raining that morning" via "Six Seconds In Dallas" p.122 <https://archive.org/details/SixSecondsInDallas>

²²<https://en.wikipedia.org/wiki/Inbetweening>

Using logic and common sense we can deduce some of what happened even though we don't have direct proof. For example we know that based on photos and witness testimony that:

- Soon after the fatal head shot at Z313 B.W. Hargis, J.M. Chaney, and D.L. Jackson stopped their motorbikes in the street, as seen in the Nix film.
- Hargis then dismounted and ran across the road in front of Chaney, as mentioned in an interview:
*"I recall it was Officer Hargis jumped off his motor and run across in front of me."*²³
- Chaney and Jackson rode away at some point:
*"I said to Jim Chaney 'Let's go with them' and we sped away"*²⁴
²⁵
- The Bell film shows Hargis standing by the lamppost (but no sign of Chaney or Jackson). The Paschall film and the Bond 4 photo also show no sign of them either.

We can then logically deduce that:

- Chaney left the scene first because he is visible in the McIntire 1 photo (see appendix E.12) but Jackson is not visible. Alternatively Chaney and Jackson left at the same time, but Chaney was travelling much faster (or a combination of both).

²³Josiah Thompson transcribed an interview from audio tape from 1971-73 <http://educationforum.ipbhost.com/topic/18602-the-law-of-unintended-consequences/>

²⁴*"The Kennedy Assassination Tapes: A Rebuttal to the Acoustical Evidence Theory"* by James C. Bowles <http://jfk.hood.edu/Collection/Weisberg%20Subject%20Index%20Files/L%20Disk/Loeb%20William%20%20Nackey%20S/Item%2001.pdf>

²⁵Notes written by "Officer C" on 1963-11-22. <http://www.jfk-online.com/bowles6.html>

We can't know the exact gap between Chaney and Jackson leaving, but the absence of one or both of them in various photos and films does allow us to know within a few seconds what happened.

By using this approach for all of the evidence we can build a fuller picture of the assassination scene than just the extant photos, films, and eyewitness testimony would allow. In other words we can build something greater than the sum of its parts.

3.5 Accuracy

As with all models, Mc63 can never exactly represent its subject. It is possible to reduce the errors to a minimum by using as many films and photos as possible. However, some errors will still persist due to the nature of the measurements, the conceptual model used, and the absence of evidence during certain parts of the sequence.

3.5.1 2D from 3D

When turning a 3D scene into a 2D model we have to discard the third dimension. In this case the map cannot reflect the height of the scene in Dealey Plaza. For example, along Elm Street the road has an incline of about 3 degrees^{26 27 28}. This will affect the accuracy of the speed calculations by less than 1%²⁹:

²⁶HSCA V.6 p.55 https://www.history-matters.com/archive/jfk/hasca/reportvols/vol6/html/HSCA_Vol6_0031a.htm

²⁷HSCA V.2 p.189 F-145 https://www.aarclibrary.org/publib/jfk/hasca/reportvols/vol2/pdf/HSCA_Vol2_0912_3_Canning.pdf

²⁸WCR CE 585 https://www.history-matters.com/archive/jfk/wc/wcvols/wh17/html/WH_Vol17_0144b.htm

²⁹<https://en.wikipedia.org/wiki/Trigonometry>

Algorithm 1 2D from 3D Error

$$\epsilon = \frac{1}{\cos(3^\circ)} = 1.00137 \quad (1)$$

$$\delta = 0.137\% \quad (2)$$

Ergo if Mc63 says a car is moving at 10 MPH down Elm Street, it will actually be 10.01 MPH. Thus we can be sure that the speed quoted is accurate to one decimal place, i.e. +/- 0.1 MPH up to 100 MPH.

3.5.2 Photo Observations

When analysing photographs it's important to avoid the trap of optical illusions. One example of this is the Altgens 6 photo³⁰ (see appendix E.6). The bike on the left hand frame is ridden by Chaney who appears to be looking directly at JFK. However, in reality the bike is far further back and so by looking across as he does he must be looking towards the other motorbikes ridden by Hargis and B.J. Martin.

3.5.3 Film Frame Rates

Most of the films taken before, during, and after the assassination were made using handheld mechanically wound devices which results in their frame rates not really being known. Every camera had its own quirks, and even devices from the same manufacturer and the same model number would vary. For example the Bell & Howell 414 PD (the same model, but a different device from the one used by Abraham Zapruder) was tested by the TV program "CBS News Inquiry - The Warren Report"³¹ in 1967 and the frame rates

³⁰Sadly Josiah Thompson fell into this trap in "Six Seconds In Dallas" p.102 <https://archive.org/details/SixSecondsInDallas>

³¹Part 1, time 46:10 <https://www.c-span.org/video/?453991-2/a-cbs-news-inquiry-warren-report-part-1>

of recording varied for the five devices from 15.3 FPS to 20.8 FPS.

In addition, we must be cautious about drawing conclusions based solely on a single frame rate, as these type of cameras would also slow down as recording progressed (see appendix C.1 for more details). With other researchers already making mistakes in this area it's important we don't treat quoted frame rates as gospel truth. The real frame rate of the films could easily be +/- 10% which has a very big influence on timings. For example, a measured time of 7 seconds during the assassination could be 6.3 seconds to 7.7 seconds in real time using this margin for error.

Instead of synchronizing with numbers, I felt it was better to synchronize with visual information in the frames of the films. For example the Zapruder, Nix, and Muchmore films all overlap around the time of the fatal shot. By studying these individual frames I concluded that the frame rates of the films were roughly the same during those few seconds. In other words if the Zapruder film was really recorded at around 18.3 FPS then the Nix and Muchmore films will be a very similar rate also.

4 The Animation

The canonical version of Mc63 is stored as an MP4 file containing a 1080p 60 FPS video and stereo 44.1 kHz audio. It visually depicts the vehicles of the motorcade moving in real time, along with some of the important witnesses, photographers, and film makers. To help people understand the events I have used semi-transparent overlays to depict photos or frames in films (yellow flashes), lines of sight of the witnesses (purple flashes), and Zapruder film evidence of bullet impacts (red flashes). More details regarding photos and events appear in the top left text box, and the speeds of the actors are listed on the right hand side. See appendix E for some sample frames, and appendix D for the exact timings of events and a list of actors.

Algorithm 2 Animation Frame Rendering

```
for ( frame = first; frame <= last; frame++ )
{
    render_map_underlay ();
    render_actors_overlay ( frame );
    render_photo_event_overlay ( frame );
    render_text_overlays ( frame );
}
```

The audio track is a sound collage³² built around the dictabelt recorded on the day of the assassination by the Dallas Police Department³³ (previously edited by Steve Barber). Other parts of the audio track are from: my own recordings; sound effects downloaded from freeSFX³⁴; which have all been mixed together to try and recreate the parade ambience from Dealey Plaza. By doing this

³²https://en.wikipedia.org/wiki/Sound_collage

³³MR84-49. Dallas Police Department. John F. Kennedy Presidential Library and Museum, Boston. <https://www.jfklibrary.org/about-us/news-and-press/press-kits>

³⁴<https://www.freesfx.co.uk>

I can better understand the witness confusion, especially regarding the shots (e.g. how many were fired, and in what timespan).

4.1 Timeline

When preparing the animation, time is broken into three contiguous parts:

- Pre-Zapruder film frame Z133.
- Zapruder film frames Z133-Z486.
- Post-Zapruder film frame Z486.

For the duration of the Zapruder film I have assumed the usual rate of 18.3 FPS. Despite this number almost certainly being wrong for much of this sequence, it is the convention for assassination research so I have stuck with it for the sake of consistency. See section 3.5 and appendix C.1 for further discussion of film frame rates.

I decided to split this timeline into three parts because it allows me to explore the possibility of a different frame rate for the Zapruder film. The computer software I have created can be adjusted to use a different frame rate for the Zapruder film, which is displayed on the status bar at the bottom of the main window (see figure 11 in appendix B.1).

4.1.1 Actor Speeds

By using the films we can determine the speeds of the vehicles. For example the Muchmore film shows us the advanced three motor-bikes as they turn from Main Street to Houston Street. This manoeuvre takes 62 frames for the lead bike (S.Q. Bellah) to go from the white line on Main Street to the white line on Houston Street.

At 18 frames per second this is about 3.4 seconds, and Mc63 has the bike travelling at about 5-8 MPH as it turns and then accelerates away.

Figure 2: Film Frames “Muchmore 168 & 230”



4.2 Map underlay

The map is a scale model of the Dealey Plaza area with measurements for the TSBD and other buildings having been checked with the HSCA^{35 36}, satellite imagery³⁷, and cross checked with contemporary photos taken in 1963. Of particular note are the lampposts and signs because they were changed fairly soon after the assassination. Other less accurate models I have seen do not faithfully reproduce the locations of these items as they use positions found in the 1970's or later. However, I need the items to be in the correct place because I use their relative positions to judge the positions of the actors via triangulation³⁸ and photogrammetry³⁹.

³⁵HSCA V.6 p.39 https://aarclibrary.org/publib/jfk/hasca/reportvols/vol6/pdf/HSCA_Vol6_2_Shots.pdf

³⁶<http://www.the-puzzle-palace.com/topo-dealey-1.png>

³⁷Google Maps <https://www.google.com/maps/place/Dealey+Plaza/@32.7786492,-96.8090798,231m/data=!3m2!1e3!4b1>

³⁸<https://en.wikipedia.org/wiki/Triangulation>

³⁹<https://en.wikipedia.org/wiki/Photogrammetry>

4.3 Actor overlay

The information I used regarding vehicles in the motorcade comes from the work of Todd Wayne Vaughan and is available from the Weisberg Collection at Hood College⁴⁰ and the Internet Archive⁴¹. The cars and buses are drawn to scale, with the humans and bikes set as fixed sized circles for clarity.

4.3.1 Mayor's Car Elm Turn

This is a very useful part of the sequence as it synchronizes several important photos and films together. It begins at Z180 (see appendix E.4) when we see the front wheel and the top of the windows of the Mayor's car passing behind the pedestrians on Houston Street just before the turn onto Elm Street. The fixed position of Zapruder and the edge of the reflecting pool makes it fairly easy to judge on the map exactly where the Mayor's car is at this point.

We also know that the Mayor's car is not visible in the Altgens 6 photo at Z255 (see appendix E.6) so we must position it to the south of this line of sight.

The next sighting of the Mayor's car is by the traffic lights when David Wiegman starts his film circa Z280 (see appendix E.7).

The speed of the Mayor's car is roughly 7-12 MPH going in and out of this turn which seems credible for a turn of this tight nature, and the speed of the vehicles ahead.

4.3.2 H.B. McLain on Houston

We first see McLain turning onto Houston Street in the Hughes film. Due to the Vice President Secret Service follow up car turning

⁴⁰<http://jfk.hood.edu/Collection/Weisberg%20Subject%20Index%20Files/M%20Disk/Motorcade%20Route/Item%2015.pdf>

⁴¹<https://archive.org/details/nsia-MotorcadeRoute/nsia-MotorcadeRoute/Motorcade%20Route%2005>

in the background we can peg this time to Z150 (see appendix E.3) as the Zapruder film shows this turn in this position at Z150 with the back of the car just to the left of the reflecting pool. McLain was in the Hughes film field of view for about a second, which based on Mc63 and the angle of view means he was travelling at about 10 MPH.

Z254 is an interesting frame because we can see some kind of white area behind camera car #2. This could be the bike of M.L. Baker, because Mc63 has him very close to that line of sight.

Lastly we have McLain in the Dorman film at around Z410 (see appendix E.9).

Throughout all this time, the speed of McLain seems about right with 10 MPH on the Main to Houston turn; 10-12 MPH along the Houston straight; and then decelerating to just under 5 MPH turning onto Elm. This speed turning the bend onto Elm Street is exactly what B.J. Martin⁴² said in his testimony (he took exactly the same tight inside line around the corner as we see in the Hughes film).

4.3.3 Zapruder & Wiegman

Circa Z447 (see appendix E.11) is a very interesting point in the animation as it roughly synchronizes the Wiegman film with the Zapruder film. In the Wiegman film we see:

- The National Press Pool car has stopped, or is stopping with its brake lights on (presumably with the Mayor's car likewise ahead).
- B.W. Hargis has dismounted to the left of the frame.

⁴²WCR V.6 p.290 https://www.history-matters.com/archive/jfk/wc/wcvols/wh6/pdf/WH6_Martin.pdf

- We can see the Presidential limo in the distance. Its flag on the right is close to one of the lampposts so I use this to triangulate with the Zapruder frame to work out the positions.
- Two objects just above the roof of the National Press Pool car resemble the size, shape, and positions of the helmets belonging to J.M. Chaney and D.L. Jackson after they had stopped their bikes.

4.4 Actor - MPH - Feet text overlay

I thought it would be useful to show how fast each actor was going at any time so I added this text box to the right hand side of the animation. If an actor is moving and it is in the visible area, then it will have its speed listed here in the order of its ID. I have also listed the total distance travelled by the actor along its route, which is useful for analysis.

4.5 Photos & Events overlay

To help viewers understand the animation with respect to the photographic and film record I added yellow flashes for moments that a photo was taken. By doing this anybody can check the veracity of my measurements by checking the positions of the actors within the yellow triangle relative to the view of the photographer.

I also added some purple flashes to depict various eyewitness events, such as when a witness saw a gun in the sixth floor window.

4.6 Photos & Events text overlay

After I first published Mc63 I received some very useful feedback from the research community⁴³. For example Pat Speer⁴⁴ suggested I have a text box to explain what photos were currently being depicted in the animation. This was a rather nice idea as it allowed me to add a small piece of text to explain what is happening at any moment. The viewer can press the pause button on the video at any time and reflect on what a witness has just seen, or which photo has just been taken.

⁴³For a full list of feedback contributors see section [G.6](#).

⁴⁴<http://www.patspeer.com>

Part III

Conclusions

While the animation I have created cannot explain the bigger picture of the assassination of JFK, it is possible to use it to determine some of what did, and did not happen in the Dealey Plaza crime scene. Specifically, Mc63 can be used to synchronize evidence; check the veracity of any theory; and to confirm or deny individual witness testimony.

Occam's Razor states:

*"Entities should not be multiplied without necessity"*⁴⁵

One of the traps that researchers sometimes fall into is to over-analyse small details (e.g. people turning their heads in the Zapruder film); then explain those details using unprovable and over-engineered speculation such as Gerald Posner⁴⁶ suggesting that the first shot hit a branch at one end of Dealey Plaza; then deflected off at a random angle; and finally struck James Tague at another end of Dealey Plaza⁴⁷. See appendix E.9.1 for a scientific experiment disproving this speculation.

The antidote to this is Occam's Razor which cuts away needless complexity by explaining all of the salient evidence using the simplest possible means. Contentious or ambiguous details can be put to one side so we only focus on independently verifiable facts (e.g. multiple independent witnesses describing the same event happening at the same time, but from a different point of view).

⁴⁵https://en.wikipedia.org/wiki/Occam%27s_razor

⁴⁶https://en.wikipedia.org/wiki/Gerald_Posner

⁴⁷"Case Closed" Chapter 14, p.324

5 Shot Sequence

Much controversy exists over the shots fired in Dealey Plaza due to conflicts between different witness statements, and different ways of interpreting events in the Zapruder film. Although I don't think it is possible to fully explain the events in Dealey Plaza using the photos, films, and witness statements, I do think it's possible to create a framework which places boundaries on the possibilities. Once this is done, we can exclude the more implausible theories and we will be left with the more likely shot scenarios.

5.1 Zapruder Film

As we can see from the Zapruder film there are two obvious signs of the victims being struck by bullets during these times:

- Z225-Z230
- Z313-Z318

These two events are unambiguously the result of gunshot wounds. Due to the Stemmons Freeway sign, the Zapruder film doesn't reveal the exact moment that the two victims were hit so the shot could have been fired from any point during Z185-Z220. If the movements we see at Z225-Z230 are the initial reactions then the gunshot was probably fired during Z210-Z220. However if this is a reaction to a second shot, then the first shot could have been fired earlier, such as Z185-Z200 (which may have missed the victims in the car).

I don't see any other obvious places in the Zapruder film where the victims are hit, or where other witnesses react to the sound of gunfire. However, the film is not a complete record of all events so shots could have been fired elsewhere in the timeline and that evidence was not recorded by the film.

As the Zapruder film and other photographic evidence can't help us locate the time of the other gunshots, we must use information from the witnesses. To this end I have completed an exhaustive survey of the witness statements in appendix F.

5.2 Earwitness Patterns

Sadly the eyewitnesses did not give a single consistent explanation of the shots. Many said there were three well spaced shots which were roughly equidistant apart. Many others said that two of the shots were closely bunched⁴⁸. Because of this apparent contradiction, I think it's impossible to say with certainty how many shots were fired.

From studying the witness statements it seems that no witness heard more than three bursts of noise during the shooting. Even A.J. Millican who says he heard eight shots, grouped those shots into three parts:

*“Just after the President’s car passed, I heard three shots come from up toward Houston and Elm right by the Book Depository Building, and then immediately I heard two more shots come from the Arcade between the Book Store and the Underpass, and then three more shots came from the same direction only sounded further back.”*⁴⁹

A large number of witnesses heard some of the shots bunched closely together, which I interpret as meaning they heard two shots within a second or two. Merriman Smith was travelling in the National Press Pool car which was in front of the TSBD during the shooting. Within minutes of the assassination he said:

*“There were three loud bursts.”*⁵⁰

⁴⁸Witness survey, appendix F.4

⁴⁹WCR V.19 p.486 https://www.history-matters.com/archive/jfk/wc/wcvols/wh19/html/WH_Vol19_0252b.htm

⁵⁰1963-11-22 UPI report https://www.newspapers.com/clip/29241344/texas_newspaper_headlines_about

James Altgens used the same word:

“There was a burst of noise—the second one I heard”

“The motorcade was moving along in routine fashion until there was a noise like fireworks popping”⁵¹

The interesting thing about these quotes is that they encapsulate both of the seemingly incongruous elements of the witness accounts:

- There were three separate well spaced shots.
- There were shots very close to each other, which some people interpreted as: firecrackers; fireworks popping; or bursts.

Some witnesses may have interpreted a single shot as two shots, as Welcome Eugene Barnett helpfully explained to the Warren Commission:

“The whole sound echoed. The sound lingered, but as far as just two definite distinct sounds, when each shot was fired, that one sound would linger in the air, but there would be nothing else until the next shot.”⁵²

In other words, there is more than one noise associated with each gunshot⁵³:

- The muzzle blast⁵⁴.
- The bullet creates a sonic boom⁵⁵ if it breaks the speed of sound.

⁵¹1963-11-22 https://www.newspapers.com/clip/30095935/kennedy_assassination_63_pt_4

⁵²WCR V.7 p.541 https://www.history-matters.com/archive/jfk/wc/wcvols/wh7/pdf/WH7_Barnett.pdf

⁵³<https://en.wikipedia.org/wiki/Gunshot>

⁵⁴https://en.wikipedia.org/wiki/Muzzle_flash

⁵⁵https://en.wikipedia.org/wiki/Sonic_boom

- The sounds of the bullet impacting its target, such as after a ricochet⁵⁶.

When considering sounds in quick succession we must also be aware of echoes and reverberations which some witnesses reported. For example Lee Bowers testified that:

*“I heard three shots. One, then a slight pause, then two very close together. Also reverberation from the shots.”*⁵⁷

5.3 Shot Burst 1 (Z180-Z240)

The exact timing of the first shot is tricky to judge, but almost all of the witnesses who gave useful timing information suggest that it was after Z180. For example Hugh Betzner and Phil Willis took photos at Z186 and Z202, which sandwiched the noise of the first shot according to their respective testimony:

Betzner - *“I took another picture as the President’s car was going down the hill on Elm Street. I started to wind my film again and I heard a loud noise.”*⁵⁸

Willis - *“Then my next shot was taken at the very—in fact, the shot caused me to squeeze the camera shutter, and I got a picture of the President as he was hit with the first shot. So instantaneous, in fact, that the crowd hadn’t had time to react.”*⁵⁹

⁵⁶<https://en.wikipedia.org/wiki/Ricochet>

⁵⁷WCR V.6 p.287 https://history-matters.com/archive/jfk/wc/wcvols/wh6/pdf/WH6_Bowers.pdf

⁵⁸Witness statement 1963-11-22 WCR V.19 p.467 https://www.history-matters.com/archive/jfk/wc/wcvols/wh19/html/WH_Vol19_0243a.htm

⁵⁹WCR V.7 p.493 https://www.history-matters.com/archive/jfk/wc/wcvols/wh7/html/WC_Vol7_0251a.htm

5.3.1 One Shot

Most reliable witnesses heard one shot in this burst⁶⁰. In most cases the witnesses also associate this shot with JFK raising his arms, which we see beginning at Zapruder frame 225. If there was only one shot in this burst this, it must have been fired a short time before Z225.

5.3.2 Two Shots

Several witnesses reported that there were two shots fired in quick succession at the beginning of the assassination. For example John Connally said he was not hit by the first shot he heard. Specifically he said he reacted to the shot that hit him “*almost close to two seconds*”⁶¹ after hearing the first shot. This exactly matches a shot fired at Z185, where he reacts 2-3 seconds later at Z224-Z240. In other words John Connally’s testimony exactly matches the Zapruder film, which offers some corroboration for this shot scenario. Here is the quote from the Warren Commission where Connally emphasises the rapidity between the first shot and his reaction:

*“I knew it when I just looked down and I was covered with blood, and the thought immediately passed through my mind that there were either two or three people involved or more in this or someone was shooting with an automatic rifle. These were just thoughts that went through my mind because of the rapidity of these two, of the first shot plus the blow that I took,”*⁶²

If this testimony is accurate, then we have two shots being fired within two seconds, which is proof of a second gunman and a probable conspiracy because Oswald wouldn’t have been able to reload and aim his bolt-action gun in those two seconds. It should also be

⁶⁰Witness survey, appendix F.5

⁶¹Press conference 1966-11-23 <https://youtu.be/uvUaJLrdoSs?t=150>

⁶²WCR V.4 p.133 https://aarclibrary.org/publib/jfk/wc/wcvols/wh4/html/WC_Vol4_0071a.htm

borne in mind that Connally has always said that he never heard the shot that hit him:

*“I have no memory, no recollection of the sound of the shot that hit me.”*⁶³

Virgie Baker and Royce Skelton support the first shot missing scenario, as they both saw the first shot hit the road near the Presidential limo (see appendix E.5). Baker located the impact as the south lane of Elm Street to the left of the limo⁶⁴:

*Baker - “looking in that direction after the first shot she saw something bounce from the roadway in front of the Presidential automobile and now presumes it was a bullet bouncing off the pavement.”*⁶⁵

*Skelton - “Mr Skelton noticed that as an open limousine turned on Elm Street, it had moved approximately one hundred feet at which time he noticed dust spray up from the street in front of the car on the driver’s side.”*⁶⁶

*“Just about the same time the car straightened up—got around the corner—I heard two shots,”*⁶⁷

“I could see the smoke coming up off the cement.”

The exact timing of this first missed shot is tricky to judge but the reaction of George Hickey helps us somewhat:

“After a very short distance I heard a loud report which sounded like a firecracker. It appeared to come from the right and rear and

⁶³Press conference in “*Rush To Judgment*” from Mark Lane and Emile de Antonio, time 19:40 https://archive.org/details/RushToJudgment_608

⁶⁴WCR CE354 https://www.history-matters.com/archive/jfk/wc/wcvols/wh16/pdf/WH16_CE_354.pdf, V.7 p.509 https://www.history-matters.com/archive/jfk/wc/wcvols/wh7/pdf/WH7_Baker.pdf

⁶⁵FBI interview 1963-11-24 WCR CD5 https://www.history-matters.com/analysis/witness/witnessMap/documents/wcd_hsca/wcd_hsca_0088a.gif

⁶⁶FBI interview 1963-12-17 CD205 https://www.history-matters.com/analysis/witness/witnessMap/documents/wcd/wcd_0087a.gif

⁶⁷WCR V.6 p.237 1964-04-08 https://www.history-matters.com/archive/jfk/wc/wcvols/wh6/pdf/WH6_Skelton.pdf

*seemed to me to be at ground level. I stood up and looked to my right and rear in an attempt to identify it.”*⁶⁸

In the Zapruder film Hickey is seen looking to his left at Z193, and he then proceeds to turn to his right up until he disappears after Z207 which is consistent with a shot fired Z180-Z185.

Jean Hill was on the south side of Elm Street and she said on the day of the assassination:

*“Two shots rang out and he grabbed his chest.”*⁶⁹

Kenneth O'Donnell was in the Secret Service follow up car and he said:

*“the first two came almost simultaneously, came one right after the other, there was a slight hesitation, then the third one.”*⁷⁰

Charles Bronson said he snapped his photo in response to the first shot noise (Mc63 suggests this moment was Z228). Bronson was about 370 feet from the sixth floor window so the sound from the gunshot would have taken 0.33s to reach him (the speed of sound being 1125 ft/sec⁷¹), with about 0.2s reaction time, and another 0.3s to press the camera button and expose the film he would have taken his photo at least 0.83s after the first shot. This means the first shot he heard was fired Z213 or before, which is a different shot to the one fired around Z220 which I presume to be the one that hit JFK and John Connally. Two days after the assassination Bronson wrote in a letter: *“I heard the first two shots ring out in rapid succession and a slight pause before the third shot rang out”*⁷².

⁶⁸1963-11-30 statement - WCR V.18 p.762 https://history-matters.com/archive/jfk/wc/wcvols/wh18/pdf/WH18_CE_1024.pdf

⁶⁹WFAA/ABC 1963-11-22 <https://www.youtube.com/watch?v=OzSy2w8E5yk>

⁷⁰WCR V.7 p.448 https://www.history-matters.com/archive/jfk/wc/wcvols/wh7/pdf/WH7_ODonnell.pdf

⁷¹https://en.wikipedia.org/wiki/Speed_of_sound

⁷²*“Pictures of the Pain”* by Richard Trask p.283

5.4 Shot Burst 2 (Z270-Z330)

5.4.1 One Shot

Most reliable witnesses heard a one shot in this burst⁷³. In the Zapruder film we see the effects of this shot at frame Z313. If this shot was fired from the sixth floor window of the TSBD it would have been fired at Z310⁷⁴

5.4.2 Two Shots

A sizeable minority of reliable witnesses heard two shots in quick succession in the second burst of gunfire. For example, Mary Woodward was standing on the north side of Elm Street as the limo passed her at the time of the first shot:

“Then the shooting—there was one shot and I have always believed it didn’t hit anybody and I think a lot of research has shown I am probably right on this because I couldn’t see anything happen and I couldn’t figure out what it was.”

“But then the next two shots came very very rapidly the sound of one didn’t kind of fade away before the second shot came.”⁷⁵

Carolyn Walther was originally standing on the eastern side of Houston Street and then walked 50 ft north to Elm Street after the Presidential limo passed her:

“At about the time they reached the curb at Elm Street, she heard a loud report and thought it was fireworks. There was a pause after

⁷³Witness survey, appendix F.6

⁷⁴It took 2 frames for the bullet to travel at 2000 ft/sec from the gun to the victim, and 1 frame for the camera to record the resulting explosion. HSCA V.6 p.27 https://aarclibrary.org/publib/jfk/hasca/reportvols/vol16/pdf/HSCA_Vol6_2_Shots.pdf

⁷⁵2015-11-07 <https://youtu.be/Eim4Pu57Fzc?t=663>

this first report, then a second and third report almost at the same time, and then a pause followed by at least one and possibly more reports.”^{76 77}

Standing with Walther was Pearl Springer who was quoted in an FBI interview as saying:

“After the Presidential party passed her and turned the corner going west on Elm Street, she heard what she thought was a shot. At first she thought it was some kind of salute, but this shot was followed by two more. She recalled that after the first shot there was a pause, then two more shots were fired close together.”⁷⁸

Corroborating Walther’s account was Ruby Henderson who is quoted in an FBI interview from 1963-12-06:

“She said after the first shot, she believes she heard two more in rapid succession, and then a fourth shot.”⁷⁹

Seymour Weitzman said:

“First one, then the second two seemed to be simultaneously.”⁸⁰

As well as civilian witnesses, the Secret Service agents in the Presidential limo and the follow up car mentioned two shots on top of each other in the second burst:

Roy Kellerman:

⁷⁶1963-12-04 FBI report WCR V.24 p.522 https://www.history-matters.com/archive/jfk/wc/wcvols/wh24/html/WH_Vol24_0270b.htm

⁷⁷“CBS News Inquiry - The Warren Report” Part 1 time 18:10 <https://www.c-span.org/video/?453991-2/a-cbs-news-inquiry-warren-report-part-1>

⁷⁸1963-12-04 FBI report WCR V.24 p.523 https://www.history-matters.com/archive/jfk/wc/wcvols/wh24/html/WH_Vol24_0271a.htm

⁷⁹WCR CE 2089 https://www.history-matters.com/archive/jfk/wc/wcvols/wh24/html/WH_Vol24_0271b.htm

⁸⁰WCR V.7 p.106 https://www.history-matters.com/archive/jfk/wc/wcvols/wh7/pdf/WH7_Weitzman.pdf

"We were still traveling at the normal rate of speed of from 12 to 15 miles per hour when I heard a noise, similar to a firecracker, exploding in the area to the rear of the car, about 12:30 p.m. Immediately I heard what I firmly believe was the President's voice, 'My God, I'm hit' I turned around to find out what happened when two additional shots rang out, and the President slumped into Mrs. Kennedy's lap and Governor Connally fell into Mrs. Connally's lap. I heard Mrs. Kennedy shout, 'What are they doing to you?'"⁸¹

George Hickey:

"After a very short distance I heard a loud report which sounded like a firecracker. It appeared to come from the right and rear and seemed to me to be at ground level. I stood up and looked to my right and rear in an attempt to identify it. Nothing caught my attention except people shouting and cheering. A disturbance in 679X caused me to look forward toward the President's car. Perhaps 2 or 3 seconds elapsed from the time I looked to the rear and then looked at the President. He was slumped forward and to his left, and was straightening up to an almost erect sitting position as I turned and looked. At the moment he was almost sitting erect I heard two reports which I thought were shots and that appeared to me completely different in sound than the first report and were in such rapid succession that there seemed to be practically no time element between them. It looked to me as if the President was struck in the right upper rear of his head. The first shot of the second two seemed as if it missed because the hair on the right side of his head flew forward and there didn't seem to be any impact against his head. The last shot seemed to hit his head and cause a noise at the point of impact which made him fall forward and to his left again."⁸²

William McIntyre:

"The Presidential vehicle was approximately 200 feet from the underpass when the first shot was fired, followed in quick succession

⁸¹1963-11-29 statement - WCR V.18 p.724-725 https://history-matters.com/archive/jfk/wc/wcvols/wh18/pdf/WH18_CE_1024.pdf

⁸²1963-11-30 statement - WCR V.18 p.762 https://history-matters.com/archive/jfk/wc/wcvols/wh18/pdf/WH18_CE_1024.pdf

by two more. I would estimate that all three shots were fired within 5 seconds. After the second shot, I looked at the President and witnessed his being struck in the head by the third and last shot.”⁸³

William Greer was driving the Presidential limo and he had some specific memories regarding the shots:

“So I heard this noise. And I thought that is what it was. And then I heard it again. And I glanced over my shoulder. And I saw Governor Connally like he was starting to fall.”

“I knew that after I heard the second one, that is when I looked over my shoulder, and I was conscious that there was something wrong, because that is when I saw Governor Connally. And when I turned around again, to the best of my recollection there was another one, right immediately after.”

“The last two seemed to be just simultaneously, one behind the other, but I don’t recollect just how much, how many seconds were between the two, I couldn’t really say.”⁸⁴

This testimony closely matches the Zapruder film: Greer is looking to the rear at Z280; he turns to the front again a few frames later; then he turns to look backwards again at Z304; after we see the effects of the shot at Z313 Greer quickly turns to the front and accelerates the car away. The comment about simultaneous shots probably relates to the Z313 shot, but it’s hard to determine exactly whether the third shot was Z313 or soon after.

Z290-Z300 is the time that Luis Alvarez tells us that the Presidential limo slowed down and the Zapruder film exhibited signs of blurring due to some kind of disturbance in Dealey Plaza⁸⁵. Alvarez speculates that this disturbance was a siren, but I suspect that the

⁸³1963-11-29 statement - WCR V.18 p.746 https://history-matters.com/archive/jfk/wc/wcvols/wh18/pdf/WH18_CE_1024.pdf

⁸⁴WCR V.2 p.117-118 https://www.history-matters.com/archive/jfk/wc/wcvols/wh2/pdf/WH2_Greer.pdf

⁸⁵“A physicist examines the Kennedy assassination film” p.35-37 <https://escholarship.org/uc/item/6615c5nn>

true explanation could be simpler because witnesses only spoke of a siren after the head shot (see section 6.1.1):

- The blur could have been due to a panning error by Zapruder which was induced by the rapid deceleration of the Presidential limo (from over 12 MPH to less than 8 MPH).
- The blur could have been due to a shot which disturbed Zapruder, as many witnesses reported just that sequence of events (including Zapruder himself who said: “*Then I heard another shot or two, I couldn’t say if it was one or two*”⁸⁶).

5.5 Shot Burst 3 (Z360-Z420)

5.5.1 Zero Shots

Most reliable witnesses did not hear a shot in this burst⁸⁷.

5.5.2 One Shot

A sizeable minority of witnesses heard a shot fired in this burst. For example Milton Wright was driving the Mayor’s car, and he said:

*“I stopped and was looking at the building when the third shot was fired.”*⁸⁸

As Mc63 shows (see appendix E.10), the Mayor’s car was stopping on Elm Street around Z400-Z430. At Z447 we see a clear frame in the Wiegman film which shows the National Press Pool car also stopped (or stopping) with its brake lights on, so the Mayor’s car would have stopped a short time before.

⁸⁶1963-11-22 WFAA-TV interview <https://youtu.be/JLqOGEBcjni?t=74>

⁸⁷Witness survey, appendix F.7

⁸⁸Vincent Palamara “*JFK: The Medical Evidence Reference*” <https://www.patspeer.com/chapter6piecesontheroad>

Robert Jackson was two cars behind Wiegman and spotted the gun in the TSBD window, which was withdrawn as the car was turning the corner:

*“I said ‘There is a gun’ or it came from that window. I tried to point it out. But by the time the other people looked up, of course, it was gone, and about that time we were beginning to turn the corner.”*⁸⁹

This statement is especially useful because we can peg the final shot to a time no later than Camera Car #3 beginning its turn onto Elm Street, which is about Z400-Z440 in Mc63. Jackson confirms this timing as he saw the Presidential limo leave Dealey Plaza:

*“As we turned the corner—or we stopped where the intersection, actually we stopped before we began to turn left onto Elm Street, or rather I would say we hesitated and we were all looking down towards the President’s car and I could see two cars going under the underpass. I barely saw the President’s car. I would say just the rear end of it as it disappeared under the underpass.”*⁹⁰

The time the limo left under the underpass was Z460-Z486, which was indeed the same time that Jackson’s car stopped according to Mc63.

We also have a group of witnesses who were close to the limo at the fatal shot (either side of Elm Street or on the overpass) who reported at least one more shot in the seconds after the fatal shot:

- Mary Moorman was standing near the limo at the time of the Z313 shot and took a photo within a few Zapruder film frames: *“There was three or four real close together. It must have been the first one that shot him because that’s the time I took the picture. And during that time after I took the picture the shots were still being fired.”*⁹¹

⁸⁹WCR V.2 p.159 https://www.history-matters.com/archive/jfk/wc/wcvols/wh2/html/WC_Vol2_0084a.htm

⁹⁰WCR V.2 p.160 https://www.history-matters.com/archive/jfk/wc/wcvols/wh2/html/WC_Vol2_0084b.htm

⁹¹WFAA/ABC 1963-11-22 <https://www.youtube.com/watch?v=YEavxZReo84>

- Charles Brehm was on the south side of Elm Street, and two days after the assassination he said during an FBI interview: *“BREHM said when the President was hit by the second shot, he could notice the President’s hair fly up, and then roll over to his side, as Mrs KENNEDY was apparently pulling him in that direction. BREHM said that a third shot followed and that all three shots were relatively close together.”*⁹²

Some years later in 1986 he added:

*“The first noise that I heard hit the President, and struck him and he raised his hand up to his neck. The car proceeded and it seemed very very slow, proceeded down just beyond me in this area when the second shot went off which absolutely destroyed the President’s head. The car then took off in a zig-zag motion down into this area when the third shot, which seemed to me to be a wasted shot went off”*⁹³

- Emmett Hudson was on the north side of Elm Street on the steps to the pergola, and was interviewed by the Warren Commission:

Mr Liebler: *“You say that it was the second shot that hit him in the head; is that right?”*

Mr Hudson: *“Yes; I do believe that – I know it was.”*

Mr Liebler: *“And after you saw him hit in the head, did you hear another shot?”*

Mr Hudson: *“Yes, sir.”*⁹⁴

Hudson was able to identify the location of limo at the time of the final shot:

“Yes; so right along about even with these steps, pretty close to even with this here, the last shot was fired-somewhere right along in there.”

Mc63 identifies this point in the timeline as Z370-Z390.

⁹²WCR CE 1425 FBI interview 1963-11-24 https://www.history-matters.com/archive/jfk/wc/wcvols/wh22/html/WH_Vol22_0434a.htm

⁹³“On Trial - Lee Harvey Oswald” by London Weekend Television 1986 <https://www.youtube.com/watch?v=K2dH9aXQbtQ>

⁹⁴WCR V.7 p.560 https://www.history-matters.com/archive/jfk/wc/wcvols/wh7/html/WC_Vol7_0284b.htm

- June Dishong was standing on the north side of Elm Street and recorded the events during the shooting in her journal⁹⁵:
 - Shot 1 - JFK *“bent forward into his wife’s lap”*.
 - Shot 2 - *“Panic among the people. Woman with children. Parents pushing them to the ground.”* is probably a reference to the Newman family protecting their family after Z313, as seen in the Nix film.
 - Shot 3 - *“A third shot. People scatter.”*

5.5.3 Two Shots

The Dallas Police lead car had several witnesses who commented on the shots that were fired. Jesse Curry was driving the car:

- *“We were just approaching an underpass, and there were some people around on each side of the underpass, up in the railroad yards, and I thought at first that perhaps this was a railroad torpedo, it was a sharp crack.”*⁹⁶
- Later he mentioned the last two shots: *“they were in pretty rapid succession”*⁹⁷
- Curry described the location of the Presidential limo at the first shot: *“To the best of my knowledge, I would say it was approximately halfway between Houston Street and the underpass, which would be, I would say probably 125-150 feet west of Houston Street.”*⁹⁸

⁹⁵<https://emuseum.jfk.org/objects/25183/june-dishong-journal>

⁹⁶WCR V.4 p.150 https://history-matters.com/archive/jfk/wc/wcvols/wh4/pdf/WH4_Curry.pdf

⁹⁷WCR V.4 p.161 https://history-matters.com/archive/jfk/wc/wcvols/wh4/pdf/WH4_Curry.pdf

⁹⁸WCR V.4 p.172 https://history-matters.com/archive/jfk/wc/wcvols/wh4/pdf/WH4_Curry.pdf

- Curry described the time span of the shots: *“This is just an opinion on my part but I would think perhaps 5 or 6 seconds.”*⁹⁹

Forrest Sorrels sat on the right rear seat:

- *“When we were at a point approximately three fourths of the distance between the Houston and Elm Street intersections and the first underpass, I heard what sounded like a rifle shot, and said ‘What’s that?’, as I turned to my right to look back in the direction of the terrace and the Texas Schoolbook Depository Building. When I heard two more shots I said, ‘let’s get out of here’.”*¹⁰⁰
- Sorrels gave more information about the shot timings in 1964: *“Within about 3 seconds, there were two more similar reports.”* *“There was to me about twice as much time between the first and second shots as there was between the second and third shots.”* *“I have called it out to myself, I have timed it, and I would say it was very, very close to 6 seconds.”*¹⁰¹

Bill Decker was in the left rear seat:

- *“As the motorcade was proceeding down Elm Street, I distinctly remember hearing 2 shots. As I heard the first retort, I looked back over my shoulder and saw what appeared to me to be a spray of water come out of the rear seat of the President’s car.”*¹⁰²

⁹⁹WCR V.4 p.172 https://history-matters.com/archive/jfk/wc/wcvols/wh4/pdf/WH4_Curry.pdf

¹⁰⁰1963-11-28 statement - WCR V.21 p.548 https://history-matters.com/archive/jfk/wc/wcvols/wh21/pdf/WH21_Sorrels_Ex_5.pdf

¹⁰¹WCR V.7 p.345 https://www.history-matters.com/archive/jfk/wc/wcvols/wh7/pdf/WH7_Sorrels.pdf

¹⁰²WCR V.19 p.458, Decker Exhibit 5323 https://www.history-matters.com/archive/jfk/wc/wcvols/wh19/html/WH_Vol19_0238b.htm

Judging from the location of the Presidential limo laid out by Curry, I would say they missed the first burst of gunfire. Also, Decker said after the first shot he saw the explosion in the Presidential limo so he certainly didn't hear the first shot 5-7 seconds before at Z185-Z220. Based on this, the occupants of the DPD lead car heard two bunched shots several seconds after the head shot (or just one shot in the case of Decker).

Jean Hill reported several shots being fired that day:

*“Mary took the picture and fell on the ground and of course there were more shots.”*¹⁰³

Moorman took her photo at Z315 and then must have dived to the ground. The final frame of the Muchmore film was taken a second or so later at around Z336, and Moorman is still standing (see figure 60). Ergo it must have taken a few more seconds for her to sit down and then the final shots Hill describes would have been fired. She added:

*“my girl friend fell on the ground after about—during the shooting—right, I would say, just immediately after she had taken the picture—probably about the third shot. She fell on the ground and grabbed my slacks and said, ‘Get down. they’re shooting.’ And, I knew they were but I was too stunned to move, so I didn’t get down. I just stood there and gawked around.”*¹⁰⁴

Hill also gave some more useful statements regarding the shot sequence of the first three shots:

“The three were fired as though one person were firing; I mean, to me. They were fired just like you could reload and fire again or whatever you do with a gun.”

The remaining shots were different though:

¹⁰³WCR V.6 p.207 https://www.history-matters.com/archive/jfk/wc/wcvols/wh6/pdf/WH6_Hill.pdf

¹⁰⁴WCR V.6 p.207 https://www.history-matters.com/archive/jfk/wc/wcvols/wh6/pdf/WH6_Hill.pdf

“I thought they were different—I thought the sequence was different.”

“Quicker—more automatic.”¹⁰⁵

Overall in terms of total shots fired she said:

“I’m saying 4 to 6. I know there were at least 4, and I just almost swear that I heard 5 or 6.”¹⁰⁶

Lee Bowers said:

“I heard three shots. One, then a slight pause, then two very close together.”¹⁰⁷

There is a useful timing and synchronization point that Bowers mentions later in his testimony:

“At the moment I heard the sound, I was looking directly towards the area at the moment of the first shot, as close as my recollection serves, the car was out of sight behind this decorative masonry wall in the area.”¹⁰⁸

Judging from a map of Dealey Plaza, Bowers could see the limo up until Z250 when it disappeared behind the pergola. This means that he is describing the shot at Z310, followed by two more around Z370-Z400. Ergo he missed the earliest shot(s) just like Mary Moorman and the occupants of the DPD lead car.

Henry Burroughs was in Camera Car #2. He said:

“My recollection was hearing four shots. It went something like this, ‘Pow’ — and we were sort of frozen — didn’t know — brought everybody to attention. There was quite a pause and then there was ‘Pow,

¹⁰⁵WCR V.6 p.207 https://www.history-matters.com/archive/jfk/wc/wcvols/wh6/pdf/WH6_Hill.pdf

¹⁰⁶WCR V.6 p.207 https://www.history-matters.com/archive/jfk/wc/wcvols/wh6/pdf/WH6_Hill.pdf

¹⁰⁷WCR V.6 p.287 https://history-matters.com/archive/jfk/wc/wcvols/wh6/pdf/WH6_Bowers.pdf

¹⁰⁸WCR V.6 p.288 https://history-matters.com/archive/jfk/wc/wcvols/wh6/pdf/WH6_Bowers.pdf

Pow, Pow,' that's the way I remembered it. The last three were in quick succession. Similar noises, echoing around the buildings."¹⁰⁹

This is an interesting recollection as he recalls the prolonged gap between the first and second shots, but all of the other shots are bunched together. It's hard to say whether shots are bunched around Z313 or Z400, or when the shooting started (i.e. Z220 or before), so these are the permutations that fit this description of the final three shots being equally spaced:

- Z185 — Z310 — Z350 — Z390.
- Z185 — Z270 — Z310 — Z350.
- Z220 — Z310 — Z340 — Z370.

This is useful corroboration for how Jean Hill described the ending of the shooting as mentioned earlier on [page 37](#) (section [5.5.3](#)).

5.6 Shot Duration

A novel way of measuring the time between the start and finish of the shooting is to use the positions of the cars on Houston Street. Malcolm Couch was in Camera Car #3 and he said this when describing his position at the first shot:

*"I would say—uh—15 or 20 feet from the turn—from off of Main onto Houston."*¹¹⁰

At the final shot, he described his position as:

*"I'd say we were about 50 feet from making—or maybe 60 feet—from making the left-hand turn onto Elm."*¹¹¹

¹⁰⁹"*Pictures of the Pain*" by Richard Trask p.398

¹¹⁰WCR V.6 p.156 https://history-matters.com/archive/jfk/wc/wcvols/wh6/pdf/WH6_Couch.pdf

¹¹¹WCR V.6 p.156 https://history-matters.com/archive/jfk/wc/wcvols/wh6/pdf/WH6_Couch.pdf

These accounts are supported by his earliest statement to the FBI within a week of the assassination:

“He said they left Love Field and were traveling the presidential route on Houston Street when he heard two loud noises about ten seconds apart which sounded like a motorcycle backfire. He said as they turned the corner onto Elm from Houston, he heard another noise”¹¹²

This ten second time span and the observations of car positions is consistent with what Mc63 depicts between Z220 and Z400, or Z185 and Z370. This account is corroborated by Thomas Dillard who was also in the same car and described the timing of the shots:

“I heard three—the three approximately equally spaced.”¹¹³

The position of the car at the first shot he said was:

“Perhaps, oh, just a few feet around the corner and it seems we had slowed a great deal. It seems that our car had slowed down so that we were moving rather slowly and perhaps just passed the turn when I heard the first explosion.”¹¹⁴

The third shot he heard was related to his car’s position in front of the TSBD:

“He states upon hearing the third shot the car in which he was riding was stopped almost in front of the Texas School Book Depository Building.”¹¹⁵

¹¹²1963-11-27 statement - WCR CD5 https://www.history-matters.com/analysis/witness/witnessMap/documents/wcd_hsca/wcd_hsca_0045a.gif

¹¹³WCR V.6 p.164 https://history-matters.com/archive/jfk/wc/wcvols/wh6/pdf/WH6_Dillard.pdf

¹¹⁴WCR V.6 p.164 https://history-matters.com/archive/jfk/wc/wcvols/wh6/pdf/WH6_Dillard.pdf

¹¹⁵1963-11-25 FBI statement - WCR CD5 https://www.history-matters.com/analysis/witness/witnessMap/documents/wcd_hsca/wcd_hsca_0049a.gif

6 Red Herrings

Because Dealey Plaza is a large crime scene with hundreds of witnesses, certain myths and red herrings have developed over the years. After completing version 1.0 of Mc63 I rejected several of these ideas due to problems relating to lack of credible evidence and plausibility.

6.1 HSCA Acoustical Analysis

The HSCA report¹¹⁶ referenced two studies from acoustics scientists^{117 118} regarding the audio recorded on a Dallas Police dictabelt before, during, and after the time of the assassination. It was claimed that this audio recording was made in Dealey Plaza by a microphone on a bike ridden by H.B. McLain, and that the recording had impulses from the gunshot sounds on it. Very specific claims were made about the position of the microphone at specific points in space and time, but these are wrong as per the Mc63 work, which uses various films to determine McLain's position:

- The position of McLain relative to the nearby cars in the motorcade is that he remains near: Camera Cars #2 or #3; Congressman Car #1. This is shown by this Dillard photo which shows his bike ID 352, just behind Camera Car #2:

¹¹⁶http://www.aarclibrary.org/publib/jfk/hasca/report/pdf/HSCA_Report_1B_Acoustics.pdf

¹¹⁷https://www.history-matters.com/archive/jfk/hasca/reportvols/vol8/pdf/HSCA_Vol8_AS_2_BBN.pdf

¹¹⁸https://www.history-matters.com/archive/jfk/hasca/reportvols/vol8/pdf/HSCA_Vol8_AS_1_Weiss.pdf

Figure 3: Photo “Dillard Early Motorcade”



- The last time we see McLain before entering Dealey Plaza is in the DCA film as the Presidential limo is about to turn onto Houston Street in the far distance, with him beside the Congressman #1 car:

Figure 4: Film Frame “DCA Main Street”



- McLain was well over 100 feet away from the corner of the Elm street turn at Z175 (where it needs to be for the acoustics

scientists to be correct), as proven by the Hughes film which shows him turning onto Elm Street at Z150. Note how McLain is still near the Congressman #1 car, which is just out of frame to the right (behind Camera Car #3):

Figure 5: Film Frame “Hughes Z150”



- At the time of the Z313 shot McLain is required to be on Elm Street but he has yet to turn onto Elm Street as shown by the Dorman film at Z410 (notice the Congressman Car #1 in the top left of the film frame):

Figure 6: Film Frame “Dorman Z410”



My observations of the animated reconstruction must therefore join the many other criticisms¹¹⁹ of the HSCA acoustics work. In particular my measurements closely resemble the results found by Dale K. Myers¹²⁰.

The only vehicle in some of the four positions indicated by the HSCA where shots were recorded, and travelling near 11 MPH, was the Mayor's car. However, for this to have recorded the shots it would have needed a stuck open microphone in a similar fashion to the motorbike which was also stuck open at the same time. While theoretically possible this seems rather implausible, and there is evidence from James C. Bowles that the only cars with police radios were the lead police car and the rear police car¹²¹. Therefore until new evidence emerges, I conclude that the HSCA acoustical findings are a red herring.

For a graphical depiction of where the microphone needs to be, consult figures: 26, 30, 32, 34.

6.1.1 Siren

Several minutes after the alleged shots on the dictabelt there are around 40 seconds of sirens blaring (see appendix D.3 on channel 1 around 12:33 to 12:34). However there are no sirens audible anywhere else on the recording around the time of the alleged shots. This is further proof that the recording was not made in Dealey Plaza as Sam Kinney in the Secret Service follow up car started his siren in the seconds following the head shot at Z313. In Kinney's statement on the day of the assassination he said:

“At this time the second shot was fired and I observed hair flying from the right side of his head. With this, simultaneously with the

¹¹⁹https://en.wikipedia.org/wiki/John_F._Kennedy_assassination_Dictabelt_recording#Criticism

¹²⁰2007-2010 <http://www.jfkfiles.com/jfk/html/acoustics.htm>

¹²¹Telephone contact, Dale K. Myers to James C. Bowles, 2005-12-14

President's car, we stepped on the gas. I released the siren at that time."¹²²

Corroboration for the siren blaring in the heart of Dealey Plaza comes from:

- Marilyn Sitzman - *"the loudest thing I heard that afternoon was the siren"*¹²³.
- Rufus Youngblood was in the Vice President's car just behind the President's Secret Service follow up car: *"I then heard two more shots. But I would like to say this. I would not be positive that I was back on that back seat before the second shot. But the Vice President himself said I was. But—then in hearing these two more shots, I again had seen more movement, and I think someone else hit a siren—I heard the noise of a siren."*¹²⁴
- Toni Foster was moving briskly across the lawn towards the presidential limo during the assassination and was clearly visible in the Zapruder film frames Z297-Z317: *"There were sirens. I can't recall the car behind them, which I'm sure was the one all the agents were in. And that fast you see gentlemen out there – all of a sudden they all had guns, rifles, light machine guns, if that is what it was."*¹²⁵
- R.E. Buster Haas: *"The motorcade continued and made its turn down the Triple Underpass and I had just commented to my wife and son about Lyndon Johnson's riding in the same car with Ralph Yarborough (after stories about their feuding) when we heard what sounded like a car backfiring about a block away. I thought to myself, "What idiot would set off a*

¹²² 1963-11-22 WCR CE 1024 V.18 p.732 https://www.history-matters.com/archive/jfk/wc/wcvols/wh18/pdf/WH18_CE_1024.pdf

¹²³ 1966 interview with Josiah Thompson <http://the-puzzle-palace.com/files/sitzman.htm>

¹²⁴ WCR V.2 p.149 https://www.history-matters.com/archive/jfk/wc/wcvols/wh2/pdf/WH2_Youngblood.pdf

¹²⁵ Interview in 1998 with Debra Conway <http://www.jfkclancer.com/pdf/toni.pdf>

firecracker or deliberately make a noise like a gun going off at a time like this?” when we heard another and then another. Someone screamed, “Oh, my God, no they couldn’t have” and everyone started moving. About the same time, the sirens started going off and the motorcycles began moving.”¹²⁶

- Robert Baskin was travelling in the National Press Pool car and noted: *“The motorcade ground to a halt. There was a good bit of activity around the President’s car, with Secret Service men running about. Before we could get out of our car, however, police sirens began wailing loudly.”¹²⁷*

If Kinney started his siren a few seconds after the head shot, Z388 seems a reasonable estimate for the time that the siren was in full force (about 4 seconds after Z313). Mc63 suggests that the car was just approaching the area of the road in front of the knoll steps:

Figure 7: Animation Frame “Z388 300 ft Siren Range”



I have included a red circle with a radius of about 300 ft, which is the distance that the HSCA said that a siren would be audible to the

¹²⁶ http://the-puzzle-palace.com/files/220068_busterhaas.html

¹²⁷ Dallas Morning News 1963-11-23.

stuck open microphone¹²⁸. This proves that the microphone was not on Houston Street, Elm Street, or Main Street in the northern part of Dealey Plaza. This includes all of the vehicles in the motorcade from the lead car back to the first press bus.

6.1.2 HSCA Animation Scenario

Another way to prove that the HSCA acoustics findings are wrong is to demonstrate what happens when McLain's bike is forced to be in the positions that the scientists thought that the microphone was located. This Hughes film frame was recorded about 3.2 seconds before the Zapruder film was restarted at Z133 (the Presidential limo is on Elm Street, obscured by the crowd):

Figure 8: Film Frame “Hughes 3.2s before Z133”



The HSCA scientists claimed that one of the shots recorded on the dictabelt was fired from the grassy knoll, and if this is aligned with Z313 then McLain's microphone recorded the first shot at about

¹²⁸HSCA report p.77 https://www.history-matters.com/archive/jfk/hasca/report/pdf/HSCA_Report_1B_Acoustics.pdf

Z175 (which is 2.3 seconds after Z133, thus the time gap between the Hughes frame above and the first shot is about 5.5 seconds). The distance between the Main Street position and the Houston Street position that this theory requires is about 200 feet, so the bike must have travelled at an average speed of 36.4 ft/sec or 24.8 MPH. In the animation there is also time required for acceleration and deceleration which pushes the peak speed up to about 30 MPH. This scenario also requires the bike we see in the Hughes and Dorman films to be accounted for, so I have assumed this must be J.W. Courson who was a short distance behind McLain in the motorcade¹²⁹.

Overall McLain and Courson have to be pushed forward by about 100-200 feet beyond where their normal motorcade positions should be relative to the other vehicles. Coupled with the preposterous speed of 30 MPH, and the inexplicable acceleration of McLain after turning onto Houston Street, this scenario defies common sense so something must be wrong with the acoustics analysis.

6.2 The Grassy Knoll

For decades conspiracy theories have hinted at a sniper firing from somewhere in the grassy knoll area to the north of Elm Street. Despite this I have found very little concrete evidence of someone firing a gun from this location. Marilyn Sitzman and Abraham Zapruder were standing in the heart of the knoll area, less than twenty yards from the picket fence to their right, and they were both very certain there were no sounds from shots fired from that area:

Zapruder - *“I’m not a ballistics expert, but I believe that if there were shots that come from my right ear, I would hear a different sound. I heard shots coming from, I wouldn’t know which direction to say,*

¹²⁹This scenario was suggest by Donald B. Thomas in *“The Bike With the Mike”* https://www.maryferrell.org/pages/Essay_-_The_Bike_With_the_Mike.html

*but they was proven from the Texas Book Depository and they all sounded alike. There was no difference in sound at all.*¹³⁰

Sitzman - *"I would say there's a very good possibility there was somebody back there, but they had a silencer. I don't know who was shooting where, but there was nobody standing behind us that close with a rifle without a silencer on it. That would have had us jumpin..."*¹³¹

These two statements suggest that the loud noises of shots that people heard did not emanate from the knoll, and must have originated from elsewhere. In other words the shots that the witnesses reported hearing probably came from the left of Zapruder and Sitzman (e.g. the buildings behind the Presidential limo).

It is often claimed that immediately after the shooting people ran up the grassy knoll to chase after an assassin. I found this to be incorrect. About 30-40 seconds after the shooting, the Bond 4 (see appendix E.13) and Towner 2 photos were taken which show nobody running up the knoll. The stampeding we see in the later films and photos seems to begin when C.A. Haygood ran up the knoll. As per the Willis 6 photo when Haygood began his dash (about 75-85 seconds after the fatal shot), the knoll is still empty. People possibly assumed Haygood was chasing an assassin, and so followed him out of curiosity.

Robert MacNeil ran up the knoll, and this was his view:

"I noticed there were policemen and plainclothesmen with guns up, running up the hill, so I ran with them."^{132 133}

The grassy knoll seems a very strange place for a professional assassin to take up position:

¹³⁰"CBS News Inquiry - The Warren Report" Part 2, time 11:50 <https://www.c-span.org/video/?454266-1/a-cbs-news-inquiry-warren-report-part-2>

¹³¹1993-06-29 interview with the Sixth Floor Museum <https://emuseum.jfk.org/objects/4679/marilyn-sitzman-oral-history>

¹³²Interviewed by Don Carleton 2000-11-18 & 2001-05-15 <https://youtu.be/C-115m1X6QE?t=590>

¹³³<https://interviews.televisionacademy.com/interviews/robert-macneil>

- The angle of view to the target is blocked most of the way down Elm Street.
- The target moves from left to right which makes an accurate shot almost impossible.
- A position behind the picket fence is completely exposed to the rear by a busy car park which means anyone passing by could see what the gunman was doing. With policemen all over Dealey Plaza, including on the triple underpass bridge, this seems rather implausible to me. A much better sniper location would be one of the tall buildings from the rear¹³⁴ such as the TSBD, the Dal-Tex, or maybe even the Dallas County Records building.

6.3 An Early Missed Shot

A common red herring is where writers discuss a missed shot before Z180, and then within a few seconds a second shot around Z210-Z220. In my research I failed to find any meaningful support for this theory among the witnesses¹³⁵. Conversely, time and again people contradicted this theory by saying that the first shot caused JFK to slump and the second shot was the fatal head shot. Typical examples of this are:

- Abraham Zapruder told the Warren Commission:
“I heard the first shot and I saw the President lean over and grab himself like this (holding his left chest area).”
*“I heard a second shot and then I saw his head opened up and the blood and everything came out and I started—I can hardly talk about it [the witness crying].”*¹³⁶

¹³⁴I have no expertise on such matters, but Joseph Milteer gave this insight into the criminal mind on 1963-11-09 <https://www.jfk-assassination.net/milteer.htm>

¹³⁵See appendix F.

¹³⁶WCR V.7 p.571 https://aarclibrary.org/publib/jfk/wc/wcvols/wh7/html/WC_Vol7_0290a.htm

- Clint Hill told the Warren Commission:

“I heard a noise from my right rear, which to me seemed to be a firecracker. I immediately looked to my right and, in so doing, my eyes had to cross the Presidential limousine and I saw President Kennedy grab at himself and lurch forward and to the left.”

“the second noise that I heard had removed a portion of the President’s head”¹³⁷

In 1975 Luis Alvarez published a report called “*A physicist examines the Kennedy assassination film*”¹³⁸. He calculated that shots were fired at Z177 and Z215, which was an update on the ideas he first shared in the 1967 TV program “*CBS News Inquiry - The Warren Report*”¹³⁹. Superficially this sounds plausible, and his arguments seem correct from a scientific perspective as they relate to measurable jiggles in the Zapruder film. If we measure this gap we are looking at 38 frames or 2.1 seconds (18.3 FPS for the Zapruder film). After seeing well trained riflemen struggle to reproduce this feat¹⁴⁰, I consider this gap to be far too short for a single gunman to reload a bolt action gun and aim accurately enough to hit a moving target. However, if there were two gunmen this is a plausible scenario. In other words, if there was only one gunman firing that day then one of these theoretical shots did not happen. Ergo I think Alvarez has either proven a conspiracy with a second sniper firing at Z215, or his film jiggle analysis has mistakenly identified a shot at Z177 or Z215 that did not actually happen.

¹³⁷WCR V.2 p.138 https://aarclibrary.org/publib/jfk/wc/wcvols/wh2/pdf/WH2_Hill.pdf

¹³⁸<https://escholarship.org/uc/item/6615c5nn>

¹³⁹Analysis of the jiggles in the Zapruder film was presented by Charles Wyckoff in CBS News Inquiry - The Warren Report Part 1, time 39:40 <https://www.c-span.org/video/?453991-2/a-cbs-news-inquiry-warren-report-part-1>.

¹⁴⁰CBS News Inquiry - The Warren Report Part 1, time 34:00 <https://www.c-span.org/video/?453991-2/a-cbs-news-inquiry-warren-report-part-1>

Other writers (e.g. Dale K. Myers¹⁴¹, Vincent Bugliosi¹⁴², Gerald Posner¹⁴³) have come to a slightly different conclusion by having the first shot at Z166 or before, and the second shot at Z223. Frame Z162 seems to be a popular point in the Zapruder film that these authors point to as a sign that John Connally turns his head to the right in reaction to a shot. Crucially these writers have rejected a simpler explanation for this head turn, which is that Connally was simply responding to the crowd. Around Z170 in the Zapruder film JFK starts raising his right arm to wave to the crowd, which seems to match Connally's actions within half a second but is clearer in terms of intent (JFK is waving to the crowd, not reacting to a gunshot, which suggests that Connally may not have been responding to a gunshot at Z162). This event was confirmed by Mary Woodward and Ann Donaldson Atterberry who were in the crowd by the lamp-post and were calling out for the President to turn to them (which he started to do around Z160). They helpfully explain these events during interviews with the Sixth Floor Museum:

Woodward - *"They were kind of talking amongst themselves in the car and I yelled out 'please look this way' because I wanted to see Jackie Kennedy. And they did look at us and waved and I think we're the last people they waved to."*¹⁴⁴

Atterberry - *"He kind of pushed his hair out of his face and smiled and waved what I thought was personally at me right here. They started on down the hill and then I heard a loud noise that I thought might have been a car backfiring or firecrackers or something."*¹⁴⁵

JFK pushed his hair at about Z136, and waved at Z175 onwards so Atterberry is ruling out the sound of a shot before Z175. I find it very difficult to believe that these and other witnesses would miss such a loud rifle shot when they were so close to the TSBD.

¹⁴¹https://en.wikipedia.org/wiki/Dale_K._Myers

¹⁴²https://en.wikipedia.org/wiki/Vincent_Bugliosi

¹⁴³https://en.wikipedia.org/wiki/Gerald_Posner

¹⁴⁴2015-11-07 <https://youtu.be/Eim4Pu57FZc?t=616>

¹⁴⁵2003-11-10 <https://youtu.be/Eim4Pu57FZc?t=918>

Hurchel Jacks drove the Vice President car and he was specific about the timing of the first shot:

*“My car had just straightened up from making the left turn. I was looking directly at the President’s car at that time. At that time I heard a shot ring out which appeared to come from the right rear of the Vice-President’s car.”*¹⁴⁶

Mc63 shows that he had just turned the corner circa Z200 (see appendix E.5) so the audible first shot must have been around that point, and not 2+ seconds before at say Z150-Z160.

Also at Z200 we see that the Presidential limo has just passed the lamppost on the north side of Elm Street. Standing beside this lamppost was A.J. Millican who said:

*“Just after the President’s car passed, I heard three shots come from up toward Houston and Elm right by the Book Depository Building”*¹⁴⁷

As can be seen at Z150 (see appendix E.3) the limo has yet to reach the lamppost so the first shot must have been fired a second or two later. Standing near this position (just a few feet to the west), and corroborating the limo position at the first shot were:

- Gloria Calvery and Karen Westbrook (see appendix E.5).
- Karan Hicks: *“The car he was in was almost directly in front of where I was standing when I heard the first explosion.”*¹⁴⁸
- Betty Jean Thornton: *“As the car in which the President was riding passed by, I heard what I thought were firecrackers being discharged”*¹⁴⁹

¹⁴⁶Statement 1963-11-28 WCR V.18 p.801 https://www.history-matters.com/archive/jfk/wc/wcvols/wh18/html/WH_Vol18_0408a.htm

¹⁴⁷Undated statement. WCR V.19 p.486 https://www.history-matters.com/archive/jfk/wc/wcvols/wh19/html/WH_Vol19_0252b.htm

¹⁴⁸FBI statement 1964-3-20 WCR V.22 p.650 https://www.history-matters.com/archive/jfk/wc/wcvols/wh22/html/WH_Vol22_0340b.htm

¹⁴⁹FBI statement 1964-3-23 WCR V.22 p.677 https://www.history-matters.com/archive/jfk/wc/wcvols/wh22/html/WH_Vol22_0354a.htm

- Jane Berry: *“Just as the car was passing by her, she heard a rifle shot.”*¹⁵⁰

Another problem with the two early shots theory is that most witnesses said there was a pronounced gap between the first and second shots. For example, between the first two shots Malcolm Kilduff¹⁵¹ was in the National Press Pool car in front of the TSBD and in a perfect position to hear the shots:

*“There was that much time for me to think and talk between the first and the second shots, despite what you hear now that they came in rapid succession they did not.”*¹⁵²

The gap between the first and second shots that Kilduff describes is therefore not consistent with the 3.8 second gap in the Zapruder film Z150-Z220. Arnold Rowland corroborates this lengthy gap with an estimate of 6-8 seconds in his statements from 1963¹⁵³ and 1964¹⁵⁴.

Pierce Allman, who was standing on the south side of Elm Street near the corner and directly in front of the TSBD. Within hours of the assassination he said:

*“Right after Mr. Kennedy passed in front of me I heard one big explosion and my immediate thought like most of the people standing around me was “this is firecrackers, but it’s in pretty poor taste”. I looked and saw the president, I thought, duck. Evidently, he was slumping at the time. The car immediately sped on. No one seemed galvanized into immediate action. The shots didn’t seem rapid at all. They were three well spaced, reverberating shots.”*¹⁵⁵

¹⁵⁰FBI report 1963-11-24 CD5 https://www.history-matters.com/analysis/witness/witnessMap/documents/Berry_0001a.gif

¹⁵¹https://en.wikipedia.org/wiki/Malcolm_Kilduff

¹⁵²Interview with Bob Hensley of WTVQ-TV 1991-11-22 <https://youtu.be/eSpw9w5GGYk?t=192>

¹⁵³WCR V.19 p.494 Sheriff’s statement 1963-11-22 https://www.history-matters.com/archive/jfk/wc/wcvols/wh19/html/WH_Vol19_0256b.htm

¹⁵⁴WCR V.2 p.182 https://www.history-matters.com/archive/jfk/wc/wcvols/wh2/pdf/WH2_Rowland.pdf

¹⁵⁵WFAA Radio interview 1963-11-22 <https://youtu.be/JGGErAUclx8?t=52>

This account is supported by Tina Towner who was standing nearby on the corner in front of the TSBD:

*“I heard three gunshots, which seemed equidistant apart and sounded, to my young ears, like firecrackers.”*¹⁵⁶

6.4 Lee Bowers

Lee Bowers said this about the Presidential limo:

*“It came in sight immediately following the last shot.”*¹⁵⁷

I originally thought this meant that the Presidential limo came into his view from behind the western side of the pergola, which would have been around Z370-Z430. However, I was informed by a 3D model of Dealey Plaza that Bowers could not see anything at Elm Street road level due to the height of the knoll blocking his view. The can be demonstrated by viewing the Bothun 5 photograph:

Figure 9: Photo “Bothun 5”

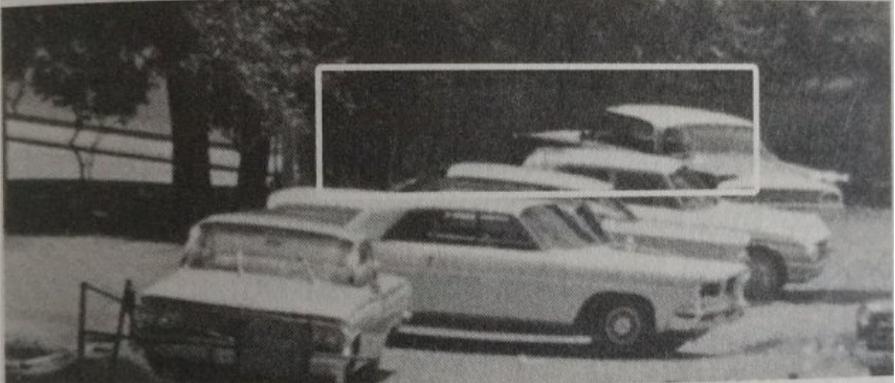


¹⁵⁶“My story as the youngest photographer at the Kennedy assassination” (2013) p.83 (Epilogue)

¹⁵⁷WCR V.6 p.288 <https://www.maryferrell.org/showDoc.html?docId=35#relPageId=298>

The tower that Lee Bowers was viewing from is just visible through the gaps of the pergola, but the height of B.W. Hargis shows any car would be too low to be seen at this or any later point. This can be emphasised by a photo taken from the tower by Josiah Thompson in 1966¹⁵⁸ which shows the gap to the west of the pergola:

Figure 10: Photo “Bowers Pergola View”



In the gap we can see a road and a footpath to the south, which is Commerce Street. This proves that the limo was not visible at this point as it was too low beneath the knoll. I don't think Bowers could have seen the limo after the shots were fired judging from the hill on either side of the railway bridge over the triple underpass so I think he must have been mistaken in his testimony.

¹⁵⁸Page 63 “*Last Second In Dallas*”

7 Final Thoughts

Luis Alvarez offers us all this sage advice at the beginning of his 1975 report:

*“Textbooks tend to indicate that problem-solving in physics is a straightforward matter; one proceeds step by step from the input data to the final answer. But in real life, as I will show, a physicist makes many mistakes, and backs up to correct them, one by one.”*¹⁵⁹

It’s very easy to make mistakes in this case due to the complexity of the crime scene, so it’s important to be wary of making too many assumptions and jumping to conclusions. For example, a week after the assassination J. Edgar Hoover said:

*“... he was hit by the first and the third, the second shot hit the Governor.”*¹⁶⁰

This was a perfectly sensible conclusion early in the investigation, but was later rejected by most people due to JFK and John Connally reacting in unison to gunshot wounds during Z224-Z240 of the Zapruder film. Other theories have come and gone over the years as people have realised that some of their earlier assumptions have proven to be incorrect.

7.1 Certainty and uncertainty

With the Dealey Plaza witnesses being so split regarding the shots (see appendix F), there are several plausible permutations of what happened. It’s very difficult to make a final complete judgement about everything, but based on the films, photos, and eyewitness statements I am certain about the following:

¹⁵⁹“A physicist examines the Kennedy assassination film” p.2 <https://escholarship.org/uc/item/6615c5nn>

¹⁶⁰1963-11-29 telephone call to Lyndon B. Johnson <https://youtu.be/E-1E7pivtss?t=509>

- Only three bursts of gunfire were fired in Dealey Plaza because no witness heard a fourth burst.
- Any witness who heard more than three shots grouped two or more shots together within just one burst (such as two shots fired within a second).
- The Zapruder film identifies when two of these bursts were fired due to the reactions of the victims at Z225 and Z313, which means the sound of gunfire reverberated around Dealey Plaza at those points in time.
- The first gunshot fired was after Z180 and became audible to the witnesses soon after. Most witnesses close to the Presidential limo associate this burst of noise with JFK's reaction we see after Z225 of the Zapruder film.
- The third burst of gunfire was fired some seconds after Z313, probably around Z360-Z400, because so many witnesses heard a shot or shots fired well after Z313.
- A sniper was located in the sixth floor window of the TSBD who fired three shots, as reported by a number of witnesses including Amos Euins¹⁶¹, Howard Brennan¹⁶², and Harold Norman¹⁶³.

These certainties are consistent with either one sniper shooting, or two snipers firing in a synchronized fashion (with a short gap such

¹⁶¹Dallas Police affidavit 1963-11-22 "I saw a man in a window with a gun and I saw him shoot twice." WCR V.24 p207 https://www.history-matters.com/archive/jfk/wc/wcvols/wh24/html/WH_Vol24_0113a.htm

¹⁶²FBI interview 1963-11-22 "Upon hearing the report, or reports, he looked across the street to the Texas School Book Depository building, where he saw a man in a window on the sixth floor near the southeast corner of the building." CD5 https://www.history-matters.com/analysis/witness/witnessMap/documents/wcd_hsca/wcd_hsca_0038a.gif

¹⁶³FBI interview 1963-11-26 "He said he thought the shot had been fired from the floor directly above him." CD? https://www.history-matters.com/analysis/witness/witnessMap/documents/wcd_hsca/wcd_hsca_0083a.gif

as a second between each pair of shots in a burst). This leaves us with a dichotomy to resolve:

- Only three shots were fired, and many witnesses were confused by echoes.
- More than three shots were fired, and many witnesses missed the extra shots as they blended into the echoes of the first shot in the burst.

One way to resolve this is to prove that one of the bursts definitely contained two shots, such as during Z180-Z220:

- There is a sequence of blurs during Z190-Z210 of the Zapruder film, which indicates a startle reaction from the noise of the first shot. Many other witnesses support this exact point in time for the first shot, such as Phil Willis who snapped a photo at Z202 and was certain that the first shot was fired just before (see section 5.3 for more examples).
- The victims both start reacting to their injuries in Zapruder film frame Z225. I think it's highly unlikely that such serious wounds could occur without some physical reaction for two seconds between Z185 and Z225 (although it's impossible to know exactly how long a reaction from a bullet wound should take to manifest itself¹⁶⁴).
- John Connally said he was not hit by the first shot, which according to Virgie Baker and Royce Skelton hit the road (see section 5.3.2 for more information).

It is also possible that two shots were fired in the Z313 burst, and maybe also the final burst Z360-Z400, although I don't think it's possible to be certain about these extra shots as there is less objective evidence:

¹⁶⁴*“There is no scientific method for determining the elapsed time between when a shot hits and when a person visibly reacts.”* HSCA p.46 https://www.history-matters.com/archive/jfk/hasca/report/pdf/HSCA_Report_1A_LHO.pdf

- An extra shot fired just before or after the fatal head shot was reported by a large number of witnesses (see section 5.4.2 for various examples).
- An extra shot fired a second or two before Z400 was reported by various witnesses (see section 5.5.3). Royce Skelton and Bill Decker¹⁶⁵ saw one of these shots hit the road.

The only lone gunman scenario that is consistent with most of the film and witness evidence is where three shots were fired during Z185-Z220, Z310, and Z360-Z400. This theory explains why the assassin slightly missed the target and hit JFK in the back (the oak tree in front of the TSBD caused a brief distraction as the gunman squeezed the trigger). The problem with this scenario is that it creates a two second time lag between Z185 and when the victims start reacting at Z225-Z230. With the Stemmons freeway sign being an obstruction in the Zapruder film during Z200-Z224, it's impossible to rule out an earlier response from the victims, but their positions and demeanour before going behind the sign are almost identical to when they emerged after Z224, so they didn't visibly react to being hit until after that point. Ergo nobody can definitively prove this theory right or wrong, but for it to have been what happened in 1963 a great deal of the witnesses must have been wrong about what they saw and heard.

None of the witnesses saw and heard every single event in those 10-12 seconds, which is why there are so many contradictions between their statements. Once you account for witnesses missing one of the bursts of gunfire then things start to make more sense, such as some saying the shooting only lasted 4-6 seconds versus those who said it lasted 8-10 seconds (thus meaning some witnesses missed the first or last burst, whereas others heard all three bursts). During such a short period of time with so many distractions in the noisy parade, it's not surprising that the witnesses missed some of these events.

Sadly my work can't solve all of the issues in the Dealey Plaza crime scene, but at least I feel somewhat better informed by debunking

¹⁶⁵ 1963-11-22 article in the Dallas Times-Herald: "*The Sheriff said he heard two shots and 'may have seen one of the bullets hit the concrete and bounce.'*"

some of the less plausible theories and finding simple explanations for previously incongruous witness testimony.

Part IV

Appendices

A Project History

A.1 Motorcade 63

Table 2: History of Motorcade 63 (2019-2021)

Version	Date	Notes
0.0	2019-02-17	Started.
1.0	2019-07-17	First published version.
1.1	2019-08-02	Minor revisions.
1.2	2019-08-09	Minor revisions. Actor speed box added to the right. Photos & Events box added to the top left.
1.3	2019-08-21	Minor revisions.
1.4	2019-09-17	Minor revisions.
1.5	2019-09-29	Minor revisions.
1.6	2019-10-31	Multiple revisions. Clock moved to top left. Map slightly enlarged.
1.7	2019-11-28	Minor revisions.
1.8	2020-01-06	Minor revisions. Distance travelled added to actor speed box.
2.0	2020-02-17	Multiple revisions. Audio track added to video.
2.1	2020-07-17	Minor revisions.
2.2	2020-12-07	Minor revisions.
2.3	2021-07-17	Minor revisions. Second animation scenario added to website (HSCA, see 6.1.2).

Table 3: History of Motorcade 63 (2022)

Version	Date	Notes
2.4	2022-07-17	Multiple revisions

A.2 This Document

Table 4: History of This Document

Version	Date	Notes
1.2	2019-08-08	Started.
1.5	2019-10-01	First published version.
1.6	2019-10-31	Minor revisions.
1.7	2019-11-28	Minor revisions.
1.8	2020-01-06	Minor revisions.
2.0	2020-02-17	Multiple revisions.
2.1	2020-07-17	Multiple revisions. Added the witness survey and dictabelt transcript.
2.2	2020-12-07	Animation data removed and put on website.
2.2.1	2021-02-17	Minor revisions.
2.3	2021-07-17	Multiple revisions.
2.3.1	2021-12-11	Minor revisions.
2.4	2022-07-17	Multiple revisions.

B The Craftsman's Tools

I built and tested Mc63 using various PC operating systems:

- CentOS¹⁶⁶, Debian¹⁶⁷, Fedora¹⁶⁸, Ubuntu¹⁶⁹, Manjaro¹⁷⁰, openSUSE¹⁷¹, Salix¹⁷².

I used Inkscape¹⁷³ to create the SVG¹⁷⁴ map underlay and also to explore possible viewing angles, and trajectories. I also used Inkscape to render the 17,000 or so bitmap frames just before I created the MP4¹⁷⁵ video.

I used Audacity¹⁷⁶ to mix the audio for the video; mhWaveEdit¹⁷⁷ to edit the wave files; SoX¹⁷⁸ to do automated batch processing before dubbing to video.

I used FFmpeg¹⁷⁹ to build the MP4 video file from the animation frames and the audio file.

I used mtCellEdit¹⁸⁰ to edit the animation data quickly and easily.

I used LyX¹⁸¹ and L^AT_EX¹⁸² to write and typeset this document.

¹⁶⁶<https://en.wikipedia.org/wiki/CentOS>

¹⁶⁷<https://en.wikipedia.org/wiki/Debian>

¹⁶⁸[https://en.wikipedia.org/wiki/Fedora_\(operating_system\)](https://en.wikipedia.org/wiki/Fedora_(operating_system))

¹⁶⁹<https://en.wikipedia.org/wiki/Ubuntu>

¹⁷⁰<https://en.wikipedia.org/wiki/Manjaro>

¹⁷¹<https://en.wikipedia.org/wiki/OpenSUSE>

¹⁷²https://en.wikipedia.org/wiki/Salix_OS

¹⁷³<https://en.wikipedia.org/wiki/Inkscape>

¹⁷⁴https://en.wikipedia.org/wiki/Scalable_Vector_Graphics

¹⁷⁵https://en.wikipedia.org/wiki/MPEG-4_Part_14

¹⁷⁶[https://en.wikipedia.org/wiki/Audacity_\(audio_editor\)](https://en.wikipedia.org/wiki/Audacity_(audio_editor))

¹⁷⁷<https://github.com/magnush/mhwaveedit>

¹⁷⁸<https://en.wikipedia.org/wiki/SoX>

¹⁷⁹<https://en.wikipedia.org/wiki/FFmpeg>

¹⁸⁰<https://ced.marktyler.org>

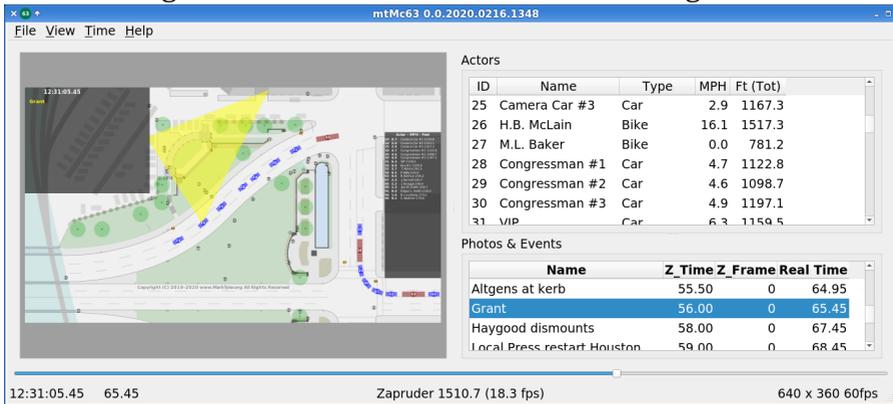
¹⁸¹<https://en.wikipedia.org/wiki/LyX>

¹⁸²<https://en.wikipedia.org/wiki/LaTeX>

B.1 Computer Programming

Each of the frames of the animation was created by a bespoke program I built for this project, which is about 3-4,000 lines of C++¹⁸³ code (according to SLOccount¹⁸⁴). Here is a screenshot of that program in action:

Figure 11: Screenshot “Motorcade 63 Program”



The graphics engine I used was Cairo¹⁸⁵ which was fast enough to use in a real time user interface and was also able to export PDF¹⁸⁶ files which I have used in this document.

I used SQLite¹⁸⁷ as the database program to hold and query the animation data.

¹⁸³ <https://en.wikipedia.org/wiki/C%2B%2B>

¹⁸⁴ <https://dwheeler.com/sloccount>

¹⁸⁵ [https://en.wikipedia.org/wiki/Cairo_\(graphics\)](https://en.wikipedia.org/wiki/Cairo_(graphics))

¹⁸⁶ <https://en.wikipedia.org/wiki/PDF>

¹⁸⁷ <https://en.wikipedia.org/wiki/SQLite>

C Anomalies

C.1 Wiegman Timing Anomaly

In “*Epipolar Geometric Analysis of Amateur Films Related to Acoustics Evidence in the John F. Kennedy Assassination.*”¹⁸⁸ on page 96, Dale K. Myers¹⁸⁹ suggests that the Wiegman film was recorded at 24 FPS. Based on my synchronizations I think it was actually recorded closer to 29 FPS.

The first problem with using 24 FPS for the Wiegman film is that it creates a timing anomaly between Z280 (see appendix E.7) when Wiegman starts filming, and Z447 (see appendix E.11) when we know that the Zapruder film and the Wiegman film can be synchronized. Myers erroneously states that Wiegman started filming between Z245 and Z247 (making 11 seconds to Z447, or 265 Wiegman film frames at 24 FPS) but this must be wrong because:

1. The Wiegman film displays the Mayor’s car in line with the traffic lights in its first clear frame after being switched on (see appendix E.7). The Mayor’s car has almost completed its turn onto Elm Street.
2. Altgens 6 is taken at Z255 (see appendix E.6) (i.e. later than Myers claimed start point for Wiegman), and yet the Mayor’s car is not visible at all (with no shadow on the road visible, so it’s not even within a few feet of the edge of the photo’s line of sight). In other words the Mayor’s car is nowhere near completing its turn onto Elm Street.
3. Items 1 & 2 are therefore contradicting each other regarding the timing and position of the Mayor’s car on the turn. In Mc63 Wiegman starts filming at Z280 (see appendix E.7) which fits perfectly with the photographic record from Wiegman and Altgens. This also fits perfectly with the speed of the Mayor’s car

¹⁸⁸2007-2010 <http://www.jfkfiles.com/jfk/html/acoustics.htm>

¹⁸⁹<http://www.dalemyersanimation.com>

from Z180 (see appendix E.4) (its last confirmed position as seen in the Zapruder film) up to Z255 when it must be just to the right of Altgens angle of view.

The second problem is that the Wiegman film seems a bit slow when viewed on the original NBC News broadcast from mid afternoon 1963-11-22¹⁹⁰. For example the flags fluttering in the wind, and the spectators waving on Main Street early in the Wiegman film seem a little sluggish and unnatural at times.

Both of these problems would be resolved if the frame rate was increased somewhat. It's important to note that if we change the rate of the Wiegman film between Z280 and Z447 we must also adjust the Zapruder film proportionately, and then Nix and Muchmore as all of these films correlate to each other during the range Z280 and Z447. Here are four example scenarios where the Z280 and Z447 gap has been adjusted to a given time, and then the required frame rates are listed for each film:

Table 5: Wiegman Film Frame Rates Z280-Z447 (Numerical)

Time (secs)	Wiegman FPS	Zapruder FPS	Nix / Muchmore FPS
8.15	32.4	20.5	20.7
9.15	28.9	18.3	18.5
10.15	26.0	16.5	16.6

As a test, if we assume that the 9.15 secs scenario is closest to what happened in 1963 then you need to replay the original broadcast at 120.42% its original speed (i.e. $28.9 / 24.0$) to get back the original speed. I have done this using my VLC¹⁹¹ media player which allows you to speed up and slow down a video. The Wiegman film looks correct under these conditions (not too fast, not too slow, especially Charles Hester jumping to his feet in a rare steady part of

¹⁹⁰<https://youtu.be/M4mUvR3WT0U?t=7850>

¹⁹¹<https://www.videolan.org/vlc>

the film). The speeds of the Zapruder, Nix, and Muchmore films are also within a plausible range (i.e. 18-19 FPS).

Another way of doing this is to extract the frames from the original broadcast, and then to re-encode them using FFmpeg at a different frame rate. Finally I viewed the resulting videos and decided whether Hester jumping to his feet looks correct or whether it was too slow or fast. Here are the results:

Table 6: Wiegman Film Frame Rates Z280-Z447 (Viewed)

MP4 FPS	% of original	Wiegman FPS	Judgement
30	100.0	24.0	Too slow
31	103.3	24.8	Too slow
32	106.7	25.6	Too slow
33	110.0	26.4	Too slow
34	113.3	27.2	OK
35	116.7	28.0	OK
36	120.0	28.8	OK
37	123.3	29.6	OK
38	126.7	30.4	OK
39	130.0	31.2	Too fast
40	133.3	32.0	Too fast

Ergo, by visual experiment I would say that this section of the Wiegman film was recorded somewhere between 27 FPS and 31 FPS.

Luis Alvarez helpfully describes scientifically what I am doing here:

“Everyone who has watched football on TV knows that it is easy to distinguish a slow motion ‘instant replay’ from the real thing, even when the play-back rate is not much slower than the normal rate. The clues come largely from our memorized knowledge of the oscillation frequency of the legs of runners moving at their fastest possible

*rates, and from our memory of the way objects fall in a 'one g' gravitational environment.'*¹⁹²

I could speculate that the Wiegman film was played back incorrectly due to the telecine¹⁹³ used by NBC to broadcast the 16mm film on television. For example if this device was calibrated to show films at 24 FPS, and convert this to the 29.97 FPS NTSC¹⁹⁴ broadcast, one extra frame was added for each 4 frames of film to match the higher frame rate (i.e. 6 extra frames per second to take the 24 FPS to 30 FPS). If the 16mm film was recorded at 24 FPS, then this transfer would look correct, but if the true recorded frame rate was higher, then the TV viewer would detect a slowness (as I do in this broadcast).

The original speed of 18.3 FPS for the Zapruder film¹⁹⁵ comes from the FBI who studied the Bell & Howell camera that Zapruder used, as well as the Nix and Muchmore cameras. The HSCA report quotes 18.3 FPS coming from the first 30 seconds of a fully wound camera¹⁹⁶.

Another part of the HSCA report gives even more details about the Zapruder film frame rates¹⁹⁷:

¹⁹²"A physicist examines the Kennedy assassination film" p.27 <https://escholarship.org/uc/item/6615c5nn>

¹⁹³<https://en.wikipedia.org/wiki/Telecine>

¹⁹⁴<https://en.wikipedia.org/wiki/NTSC>

¹⁹⁵https://en.wikipedia.org/wiki/Zapruder_film

¹⁹⁶HSCA V.6 p.27, p.30 https://aarclibrary.org/publib/jfk/hasca/reportvols/vol6/pdf/HSCA_Vol6_2_Shots.pdf

¹⁹⁷HSCA V.5 p.722-723 https://history-matters.com/archive/jfk/hasca/reportvols/vol5/html/HSCA_Vol5_0363b.htm

Table 7: Measured Zapruder Film Frame Rates

Period (secs)	FPS
0 - 10	18.0 - 18.1
10 - 30	18.3 - 18.5
30 - 40	18.1
40 - 60	17.6 - 17.9

Due to the mechanical nature of the cameras in 1963 we can never be certain of exactly what the frame rate of the devices was when recording the film. As proven by the FBI tests these cameras slow down and speed up during recording, so no single figure can ever be 100% accurate throughout a continuous sequence. However, the ranges quoted in table 5 are close enough to the expected values numerically and by visual observation of the films. Ergo the timing in Mc63 during Z280-Z447 can be assumed to be approximately correct.

C.2 Towner Timing Anomaly

In “*Epipolar Geometric Analysis of Amateur Films Related to Acoustics Evidence in the John F. Kennedy Assassination.*”¹⁹⁸ on page 55, Dale K. Myers¹⁹⁹ calculated that the Towner film was recorded at 22.8 FPS. By contrast Gary Mack from the Sixth Floor Museum has suggested that the film was recorded at around 18 FPS:

“But the Dealey Plaza footage was at the end of the reel and, as is well-known from camera tests of Zapruder, Nix and Muchmore, camera speeds varied by 5% or more from beginning to end and each film scene speed depends on several variables. Our transfer of the entire Towner reel was made at 20 fps, which is more than 10% faster than normal (which was almost certainly 18fps). The transfer probably shows the limo moving too fast. That, of course, is not a significant visual problem but it would wreak havoc with anyone using the video transfer to establish the camera’s true speed.”

Since joining the Museum in 1994, I have personally overseen the film to tape transfers of the 8mm camera original Bronson, Hughes, Bell, Towner and Dorman films, the first generation Nix and Zapruder films, and many others showing motorcade scenes prior to Dealey Plaza. Those amateur cameras ran at either 16fps or 18fps, +/- several percentage points. With the exception of the Towner film, all were transferred at either 16 or 18fps, whichever produced the most natural movement. The film technician who has done all of the transfers has been providing his service for a couple decades; he has literally viewed hundreds and hundreds of films and has a superb eye and “feel” for the appropriate speed. The difference between 16fps and 18fps may seem small, but it is glaringly noticeable when viewed on professional monitors

The Towner film’s true speed is likely closer to 18fps or slightly faster for most of the reel than to any other speed; it certainly was not operating at 16fps on November 22, 1963.

¹⁹⁸2007-2010 <http://www.jfkfiles.com/jfk/html/acoustics.htm>

¹⁹⁹<http://www.dalemyersanimation.com>

Gary Mack”²⁰⁰

The difference between 18 FPS and 22.8 FPS is a 26.7% increase, which is significant. To establish the correct speed we need to compare the Towner film to the Hughes film, as they both share a 4.8 second overlap which allows us to judge the relative speed ratio of the two films.

As shown in appendix E.2 and table 12, I think the most likely rate for the Hughes film is around 18 FPS. By using this as a benchmark we can measure how fast the Towner film was recording as they recorded the same scene from a different angle.

The Towner film segment of interest is 160 frames, with 7 frames missing²⁰¹, thus totalling 167 frames at an unknown frame rate. On the animation map I have measured the positions of the vehicles at the start and end points, and the gap between the Presidential limo start and finish positions is 104.0 ft.

The Hughes film segment is 4.8 seconds at a frame rate of 18 FPS²⁰². The distance the Presidential limo travels from start to finish is 64.3 ft. The limo isn’t visible at the end of this segment but its position can be estimated as the follow up Secret Service car is so close to it. Therefore the limo is travelling at 13.4 ft/sec (64.3 ft / 4.8 secs) or 9.1 MPH on average as it turned that part of the corner.

I have assumed that 9.33 MPH is the average speed during the whole of the Towner segment (slightly faster than the 9.1 MPH during the Hughes film due to accelerating out of the bend after Hughes stopped filming). 39.7 ft is the gap between the Hughes limo distance travelled and the Towner distance travelled, i.e. 104.0 minus 64.3. This means that the time taken to film the Towner segment is 7.6 seconds (104.0 ft / 13.68 ft/sec (9.33 MPH)).

²⁰⁰<http://educationforum.ipbhost.com/topic/23627-zapruder-film/page/2/?tab=comments#comment-346994>

²⁰¹p.53-54 “*Epipolar Geometric Analysis of Amateur Films Related to Acoustics Evidence in the John F. Kennedy Assassination.*” 2007-2010 Dale K. Myers

²⁰²As measured from the version of the Hughes film from the Sixth Floor Museum.

Finally, I can now calculate the frame rate which is 167 frames / 7.6 secs or 22.0 FPS. Myers calculates 22.8 FPS, but this is with the Hughes film at a higher rate of 18.3 FPS. After adjusting the Hughes film to this higher rate, my Towner film rate becomes 22.4 FPS which is within 2% of his 22.8 FPS. Therefore I conclude that the 18 FPS Towner figure is far too low and the correct Towner figure is approximately 22.0-22.8 FPS relative to the Hughes film being recorded at 18.0-18.3 FPS.

All of these assumptions and results seem to create a smooth sequence in the animation so I suspect they are close to the real figures from 1963. Here are the animation frames with the figures I have used:

Figure 12: Animation Frame “Towner Film Start”



Figure 13: Animation Frame “Hughes Film Start”



Figure 14: Animation Frame “Hughes Film Finish”



Figure 15: Animation Frame “Towner Film Finish”



D Animation Data

The raw animation data can be downloaded directly from my Mc63 website.

D.1 Actors

https://www.marktyler.org/mc63/mc63_actors.csv

D.2 Photos and Events

https://www.marktyler.org/mc63/mc63_photos.csv

D.3 Dictabelt Audio Transcript

https://www.marktyler.org/mc63/mc63_dictabelt.csv

E Sample Animation Frames

E.1 Moorman 3

Figure 16: Animation Frame “Moorman 3”



This is the moment that Mary Moorman²⁰³ took one of her Polaroid photos.

Figure 17: Photo “Moorman 3”



²⁰³https://en.wikipedia.org/wiki/Mary_Moorman

E.2 Weaver

Figure 18: Animation Frame “Weaver”



This is the moment that Jack Weaver snapped his Polaroid photo of the Presidential limo turning from Main Street onto Houston Street. At exactly this time there were also three films being recorded: Zapruder, Hughes, and Muchmore. This makes it a very good sync point for analysis.

Figure 19: Photo “Weaver”



E.2.1 Weaver & Zapruder Z035

The common feature between the Weaver photo and the Zapruder film is the position of the bike ridden by W.G. Lumpkin. I have measured this position by triangulating Zapruder's position and Weaver's position on the map relative to the corners of the TSBD and the Dal-Tex building (about 42% of the total distance between the corners). This locates the frame as Z035²⁰⁴:

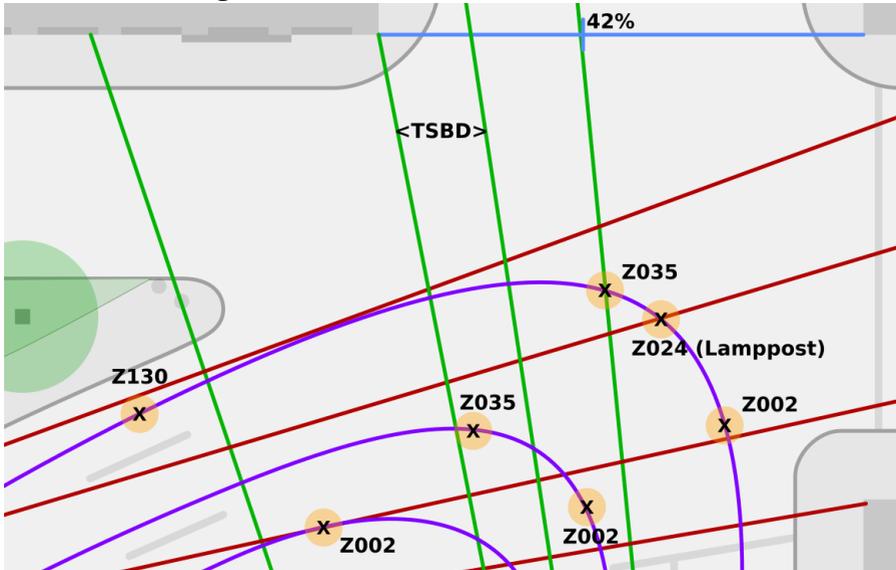
Figure 20: Film Frame "Zapruder Z035"



- The bike in the middle lane, ridden by L.E. Gray is not visible in the Weaver photo because the DPD Lead car is obscuring it.
- The bike in the left hand lane, ridden by Stavis Ellis is not visible in the Weaver photo because the spectators on the edge of the pavement by the reflecting pool wall are obscuring it.

²⁰⁴<https://www.assassinationresearch.com/zfilm/z035.jpg>

Figure 21: Construction lines “Weaver”



The construction lines in figure 21 show the geometry of my workings:

- In the Weaver photo Lumpkin is in line with 42% between the TSBD and the Dal-Tex building corners, which is exactly where he needs to be relative to the Zapruder film (he was in line with the lamppost at Z024). The animation shows that he gently slowed from 12 MPH to 10 MPH as he took this wide corner. Gray in the middle lane was a bit slower at about 8 MPH as his corner angle was slightly tighter, which is shown in the Zapruder film Z002-Z035 (figure 20, where he is seen tilting to his left).

E.2.2 Weaver & Muchmore

The common features between the Weaver photo and the Muchmore film are:

- JFK is pushing his hair back, and displaying a pointed elbow.
- The two bikes to the right of the limo are very close to the white line separating Main Street from the junction.

These features narrow the Muchmore frames down to 267 - 272, so I have chosen 267 as the point closest to the Weaver photo being taken:

Figure 22: Film Frame “Muchmore 267”



Later on in this segment of the Muchmore film we see Phil Willis preparing to take his photo number “3”:

Figure 23: Film Frame “Muchmore 425”



This allows me to calculate the average limo speed turning the corner and accelerating along Houston Street:

Table 8: Muchmore Houston Limo Positions

Photo	Muchmore (frame)	Limo (ft)	Time (secs)
Weaver	267	483.3	-33.74
Willis 2	338.6	523.9	-29.84
	425	590.5	-25.14
Willis 3		598.2	-24.70

Table 9: Muchmore Houston Limo Speeds

Frame A-B	Time (secs)	Distance (ft)	ft/sec	MPH
267 - 338.6	3.90	40.6	10.4	7.1
338.6 - 425	4.70	66.6	14.2	9.7
425 - Willis 3	0.44	7.7	17.5	12.0

Mc63 calculates the Houston Street limo peak speed to be about 12-13 MPH soon after the Willis 3 photo was taken.

E.2.3 Muchmore & Hughes

One way of checking the relative speeds between the Muchmore and Hughes films is to measure the rate of blinking on the front lights of the Presidential limo.

Table 10: Muchmore Limo Light Blinks

Left on	Right on	Left Gap	Right Gap
248-258			
	258-264	16	
264-274			16-17
	274-281	16-17	
281-290			16-17
	290-298	17	
298-307			17
	307-?		

Therefore the average gap in the Muchmore film is 16.58 frames per blink cycle.

Table 11: Hughes Limo Light Blinks

Left on	Right on	Left Gap	Right Gap
?-453			
	453-465	27	
465-480			28
	481-493	28	
493-508			27
	508-520	26-27	
520-534			26
	534-?		

Therefore the average gap in the Hughes film is 27.08 frames. The video from the Sixth Floor Museum was playing back at 30 FPS

and was created from assuming that the film was recorded at 18.0 FPS²⁰⁵, then the frames per cycle is 16.25 (i.e. $27.08 / 30 * 18$).

In other words the Hughes and Muchmore films were recorded at a very similar rate in 1963 with a ratio of (16.58 : 16.25) for that particular set of frames. This means that the Muchmore frame rate was 18.37 FPS if the Hughes film was 18.0 FPS (i.e. $18 * 16.58 / 16.25$).

E.2.4 Zapruder Z130 & Muchmore & Hughes

Z130 is the last clear Zapruder frame of the first sequence, and shows very clearly that the DPD Lead car has yet to start its turn onto Elm Street. In the animation I have placed the car just behind the wall of the reflecting pool as per this animation frame. We don't know the exact position of the DPD Lead car because it is obscured, but the value of this judgment is that by putting it here we put a limit on the final Zapruder film frame rate later on in table 12. Conversely if the Zapruder frame rate was any slower, the DPD Lead car would be visible in Z130.

This is also when Hughes catches the car starting its turn:

²⁰⁵ <https://emuseum.jfk.org/objects/23202/robert-hughes-film>

Figure 24: Animation Frame “Hughes DPD Lead”



I judge this point to be frame 745 of the Hughes film (from the 30 FPS video built from the 18 FPS original film) when the DPD Lead car starts to move into the turn and:

- The rear of the Presidential limo is roughly level with the final white line commencing Houston Street (see fig 24).
- JFK has just straightened himself up at this point and then turns to his left to speak to others in the car, which allows me to match this point in the Hughes film to frame 362 of the Muchmore film.

We have the Weaver Muchmore point at frame 267, with frame 362 when the DPD Lead car starts its turn when Zapruder stops filming. This period is 5.17 seconds (i.e. (362-267) / 18.37) if the Hughes film is 18 FPS.

We can then deduce the Z035 frame in Hughes which is 590 (i.e. 745 - 30*5.17). In the Hughes frame we see Nellie Connally is beginning to turn her head to the left, which means that it cannot be any later

than this, because in the Weaver photo she is looking straight ahead (which is consistent with Hughes frame 598 or before, so we have no contradiction).

E.2.5 Relative Frame Rates: Z035-Z130, Hughes, Muchmore

Now we know the Hughes/Muchmore film speed relationship, and we have a measurement for Z035 and Z130 I can calculate the relative frame rate for each film. There is no way to know the exact frame rates from 1963, but we can study the ratio between the films and develop a few possible scenarios:

Table 12: Zapruder Hughes Muchmore Frame Rates Z035-Z130

Time (secs)	Zapruder FPS	Hughes FPS	Muchmore FPS
4.7	20.2	19.8	20.2
4.9	19.4	19.0	19.4
5.17	18.4	18.0	18.4
5.3	17.9	17.6	17.9
5.7	16.7	16.3	16.7

Zapruder FPS = 95 frames / Time.

Hughes = 18 (FPS) * 5.17 / Time.

Muchmore FPS = Hughes * 16.58 / 16.25.

E.3 Z150

Figure 25: Animation Frame “Z150”



This is the synchronized point between the Zapruder film and the Hughes film:

- H.B. McLain is turning from Main Street onto Houston Street.
- The VP Secret Service follow up car has just started its turn (positioned in the Zapruder film by the edge of the reflecting pool).

E.4 Z188

Figure 26: Animation Frame “Z188”



This frame is just after the Mayor’s car was last seen in the Za-pruder film in the background of Z180.

Just a second or two later Elizabeth “Dearie” Cabell looked up and spotted the gun in the sixth floor window:

“I saw a projection out of one of those windows. Those windows on the sixth floor are in groups of twos.”²⁰⁶

Dearie had a very keen eye. She also said:

“I am completely aware of the people running up that hill. I saw the man throw the child on the ground and throw himself. I saw a woman in a bright green dress throw herself on the ground. I saw the policeman running up the grassy slope.”

²⁰⁶WCR V.7 p.486 http://aarclibrary.org/publib/jfk/wc/wcvols/wh7/pdf/WH7_MrsEarleCabell.pdf

Mc63 shows that she was talking about William Newman and his family on the grass as she had a very clear view of this area (see appendix E.11 for a view from behind the Mayor's car proving this). The policeman she mentions was possibly B.W. Hargis who had just run across the road as she drove past. He didn't run up the grass slope, so perhaps she was assuming David Wiegman was a policeman as he was running up the knoll at this point? The woman in the bright green dress is probably Beatrice Hester who fell to the ground just after the Mayor's car stopped²⁰⁷ (or possibly Doris Mumford who was seen on the grass near the Newman family in the Wiegman film: see figure 40). Either way, everything Cabell said seems to be corroborated by other evidence thus proving her reliability as a witness.

²⁰⁷Hester was wearing a bright green dress as shown by a pre-motorcade frame of the Zapruder film: <https://sites.google.com/site/lightboxzframes/lightbox-frame-sets>

E.5 Z200, Z175, Z215

Figure 27: Animation Frame “Z200”



This animation frame shows where Karen Westbrook and Gloria Calvery were standing together on the pavement, with the Presidential limo directly in front of them:

Westbrook: *“The car he was in was almost directly in front of where I was standing when I heard the first explosion.”*²⁰⁸

Calvery: *“The car he was in was almost directly in front of where I was standing when I heard the first shot.”*²⁰⁹

This animation frame also shows that Royce Skelton and Virgie Baker were both able to see the impact of the stray bullet that they said hit the road near the limo after the first shot was fired (see chapter 5.3.2). Baker would not have been able to see this impact

²⁰⁸FBI statement 1964-03-19 WCR V.22 p.679 https://www.history-matters.com/archive/jfk/wc/wcvols/wh22/pdf/WH22_CE_1381.pdf

²⁰⁹FBI statement 1964-03-19 WCR V.22 p.638 https://www.history-matters.com/archive/jfk/wc/wcvols/wh22/pdf/WH22_CE_1381.pdf

before Z175 or after Z215 due to other cars blocking her view, so the first shot must have been fired within this two second period and nowhere else. Here are those reference frames:

Figure 28: Animation Frame “Z175”



Figure 29: Animation Frame “Z215”



Other witnesses also support Z175-Z215 being the time of the first shot (see section 5.3 for more detailed information, and other research^{210 211}):

- Phil Willis took a photo circa Z202 immediately after the first shot.
- Charles Bronson took a photo circa Z228 in response to the first shot (which is far too soon to react to a shot fired at Z220).
- John Connally heard a shot fired two seconds before he was hit, which the Zapruder film shows to be Z225. Two seconds before Z225 is Z188.
- Abraham Zapruder moved suddenly for about a second for some reason and blurred his film Z190-Z210. It is reasonable to conclude that the first shot would have startled him enough to cause such a reaction.
- Hurchel Jacks was driving the Vice President's car and had just turned onto Elm Street when he heard the first shot (see section 6.3) which matches the car position at Z200.
- A.J. Millican said the limo had just passed him at the lamp-post when the first shot was fired which is consistent with Z190-Z200 and not before (see section 6.3).
- George Hickey said he started turning to his right after the first shot, which can be seen happening just after frame Z193 of the Zapruder film.

All of this witness evidence taken together rules out the first shot being fired before Z175 or after Z215, with the most likely time of the shot being fired around Z180-Z190 of the Zapruder film which

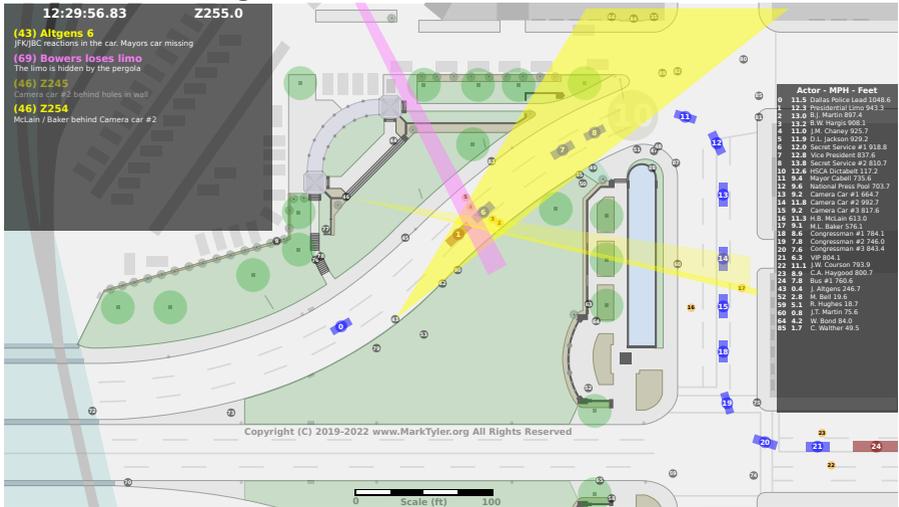
²¹⁰Barb Junkkarinen - Kennedy Assassination Chronicles (summer 1999) <http://www.jfklancer.com/pdf/bj190.pdf>

²¹¹Douglas DeSalles - Kennedy Assassination Chronicles (fall 1999) <http://jfk.hood.edu/Collection/Weisberg%20Subject%20Index%20Files/D%20Disk/DeSalles%20Douglas%20MD/Item%2001.pdf>

would have been audible to the witnesses during the following half second or so (Z190-Z200) when all of the reported events seem to start happening.

E.6 Z255

Figure 30: Animation Frame “Z255”



This frame is roughly when the Altgens 6 photo was snapped. It is widely quoted as being at Z255 of the Zapruder film although it could have been as early as Z253²¹².

As proven by the Zapruder film and the Bronson 3 photo from circa Z228, the bikes are well to the rear of the limo so J.M. Chaney is not looking at JFK (it’s an optical illusion in the photo).

²¹²Brian T. Kelleher judges Altgens 6 to be Z253 on page 55 of his book *“The Complete Unraveling of the JFK Assassination: A Lost Bullet’s Deadly Trail”*. Judging from Mc63 and assessing the relative position of the Presidential limo and the white road marking he could well be correct. The visual matching from the Zapruder film to the Altgens photo is somewhat tricky as the angles are so different, but my own judgement is that the Altgens 6 photo was taken somewhere around Z253-Z255.

Figure 31: Photo “Altgens 6”



E.7 Z280

Figure 32: Animation Frame “Z280”



Just before the fatal shot was fired, David Wiegman started his film²¹³ and caught the traffic lights behind the Mayor’s car, and the National Press Pool car is seen in front of the TSBD entrance.

Figure 33: Film Frame “Wiegman 6”



²¹³NBC News 1963-11-22 <https://youtu.be/M4mUvR3WtO?u?t=7850>

E.8 Z313

Figure 34: Animation Frame “Z313”



Here is when the effects of the fatal shot to JFK become visible in the Zapruder film.

Just before Z313 the Dorman film shows the Mayor’s car passing the traffic lights.

E.9 Z410

Figure 35: Animation Frame “Z410”



Z410 is where the Dorman film depicts H.B. McLain turning from Houston onto Elm Street.

In this animation frame we can imagine a possible bullet trajectory from the sixth floor TSBD window to the kerb near James Tague on the south side of Main Street near the rail-road bridge. The gunman would have needed to cope with the limo accelerating away and turning right sharply so perhaps he rushed the shot, it went slightly wide, thus hitting the road, with the resulting ricochet²¹⁴ shrapnel being directed towards Tague. A bullet hitting the road near the limo was reported by Royce Skelton²¹⁵. It's also possible that the shrapnel that hit Tague in the face was not the same piece that hit the kerb.

²¹⁴An example of a bullet ricochet: <https://www.youtube.com/watch?v=LZEyDGxJwAk>

²¹⁵WCR V.6 p.238 <https://www.maryferrell.org/showDoc.html?docId=35#relPageId=248>

Skelton's initial statement from the day of the assassination is worth reflecting on, as it would come from a fresher memory than his later statements:

*"I was standing on top of the train trestle where it crosses Elm Street with Austin Miller. We saw the motorcade come around the corner and I heard something which I thought was fireworks. I saw something hit the pavement at the left rear of the car, then the car got in the right hand lane and I heard two more shots. I then heard a woman say 'Oh no' or something and grab a man inside the car. I then heard another shot and saw the bullet hit the pavement. The concrete was knocked to the South away from the car. It hit the pavement in the left or middle lane."*²¹⁶

Skelton mentions four shots like his WCR statement, but he gives some interesting details regarding where the bullet hit the road, and the order of the shots. He also mentions that the limo changed lane which is circa Z400-Z450, corroborating the time of the final shot in Mc63.

Just before Z410 James Altgens snapped the so called Altgens 7 photo. If you look closely you can just make out the outline of Bill Decker in the left rear seat of the lead car as he watches the Presidential limo (he saw the bullet hit the road at around this time). In the full version of this photo you can also see Skelton and Austin Miller standing on top of the underpass bridge (near Sam Holland)²¹⁷.

²¹⁶HSCA V.5 p.537 https://history-matters.com/archive/jfk/hasca/reportvols/vol5/pdf/HSCA_Vol5_1229_1_Narration.pdf

²¹⁷"Six Seconds In Dallas" p.61 <https://archive.org/details/SixSecondsInDallas>

Figure 36: Photo “Altgens 7”



While being questioned in the Sheriff’s office after the assassination, Jean Hill made a reference to a Secret Service agent who saw something hit the road near her:

“Then, he asked me I was asked did I know that a bullet struck at my feet and I said, “No; I didn’t.” And he said, “What do you think that dust was?” And I said, “I didn’t see any dust.””²¹⁸

Sadly Hill wasn’t able to name the Secret Service agent, but it may have been Forrest Sorrels who was in the Sheriff’s office soon after the assassination:

“And I also asked if he had seen anybody else. and he pointed to a young colored boy there, by the name of Euins. And I got him and Mr. Brennan, and I took them over to the sheriff’s office where we could get statements from them.”²¹⁹

E.9.1 Road Crater

At this point in my research I asked myself:

²¹⁸WCR V.6 p.221 https://www.history-matters.com/archive/jfk/wc/wcvols/wh6/pdf/WH6_Hill.pdf

²¹⁹WCR V.7 p.349 https://www.history-matters.com/archive/jfk/wc/wcvols/wh7/pdf/WH7_Sorrels.pdf

- What would happen to a bullet striking an asphalt road?

Helpfully NOVA²²⁰ PBS²²¹ conducted an experiment with the help of Michael Haag and Luke Haag²²² to see what would happen if a bullet hit asphalt, which demonstrated that:

- The bullet hitting the road would kick up some debris that could be seen by witnesses.
- A bullet hitting a tree branch in the oak tree near the TSBD would not be directed towards Tague (i.e. ruling out a deflected shot as early as Z150-Z170 hitting Tague).

Ergo after hitting the road the bullet would have disintegrated and thrown up some dust and debris that was seen by Decker, Miller, and Skelton. Then it left behind a small crater in the road before some of the shrapnel fragments hit Tague and the kerb in front of him.

The final proof that a shot at Z400 could have been responsible for Tague's injuries is a view from the snipers perch to see if it lines up. As a visual reference from the sixth floor of the TSBD, this photo shows a possible road strike point (red box); how it relates to where Tague was standing (yellow box); and the manhole cover area (white box):

²²⁰ [https://en.wikipedia.org/wiki/Nova_\(American_TV_program\)](https://en.wikipedia.org/wiki/Nova_(American_TV_program))

²²¹ <https://en.wikipedia.org/wiki/PBS>

²²² "The Shot That Missed" 2013 <https://www.youtube.com/watch?v=iiUv2WQKBjo>

Figure 37: Photo “Road Crater Location Z400-Z410”

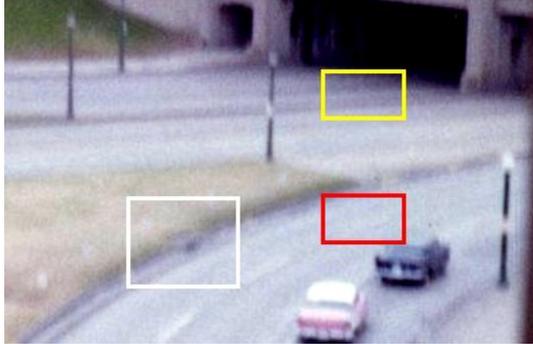


Photo source: Twitter / Sixth Floor Museum²²³

The Presidential limo would have been in a similar place to the black car (further to the left into the centre lane, and slightly further forward down the hill past the lamppost). In other words the trajectory is correct from above as the animation shows, and is also correct from the assassin’s eye view. If this is what happened in 1963, then the assassin very nearly shot Clint Hill (as he was standing on the rear left of the limo at that time as per Altgens 7). It would have been a very difficult shot though, as the car was traveling over 20 MPH at that time and swerving to the right.

While appendix E.9.1 is not absolute proof of what happened in 1963, it does demonstrate the theory is possible because it is consistent with the physical evidence and the witness testimony.

²²³Tweet from <https://twitter.com/SixthFlrMuseum> on 2019-04-26 - “The photo on the left was taken from the sixth floor of the TSBD building on November 26 or 27, 1963.” <https://t.co/XuyUGQKdw1>

E.10 Z420

Figure 38: Animation Frame “Z420”



Milton Wright and David Wiegman would have started to react to the final shot by this point.

E.11 Z447

Figure 39: Animation Frame “Z447”



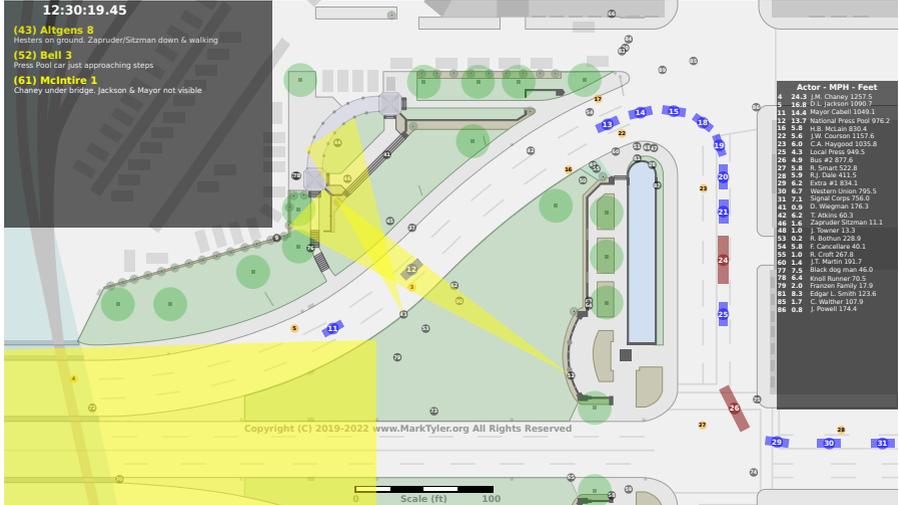
A couple of seconds or so after the final shot, the Zapruder film and the Wiegman film can be synchronized (Wiegman had just started his sprint down Elm Street).

Figure 40: Film Frame “Wiegman 265”



E.12 McIntire 1

Figure 41: Animation Frame “McIntire 1”



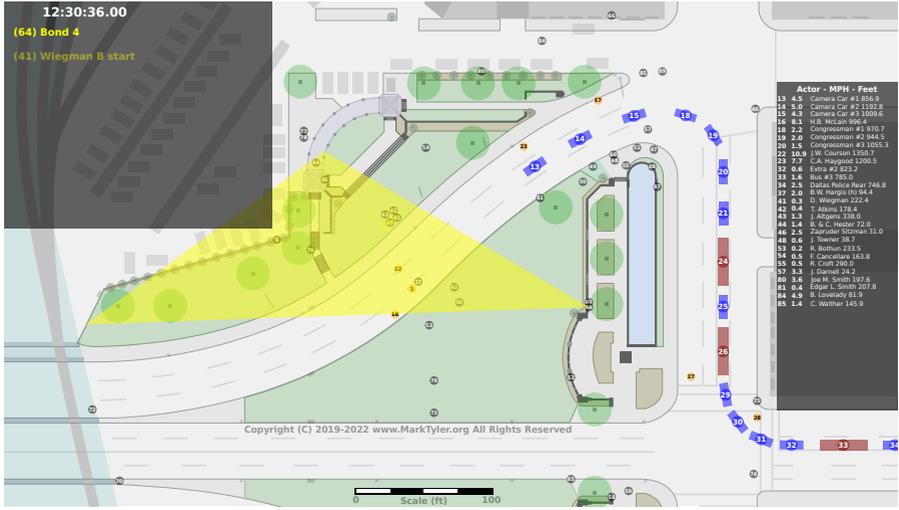
Mel McIntire’s photo places J.M. Chaney under the bridge about 15 seconds after the final shot was fired. D.L. Jackson and the Mayor’s car have yet to come into view from behind the bridge. James Altgens has just taken his final photo.

Figure 42: Photo “McIntire 1”



E.13 Bond 4

Figure 43: Animation Frame “Bond 4”



About thirty seconds after the shooting stopped Wilma Bond took her first post assassination photo:

Figure 44: Photo “Bond 4”



E.14 Atkins films Wiegman

Figure 45: Animation Frame “Atkins films Wiegman”



This frame catches David Wiegman running back to Camera Car #1 as filmed by Thomas Atkins. The black line overlay shows Wiegman’s run around Dealey Plaza during the sixty seconds or so after the assassination.

Figure 46: Film Frames “Atkins films Wiegman 1 & 2”



E.15 Cabluck 2

Figure 47: Animation Frame “Cabluck 2”



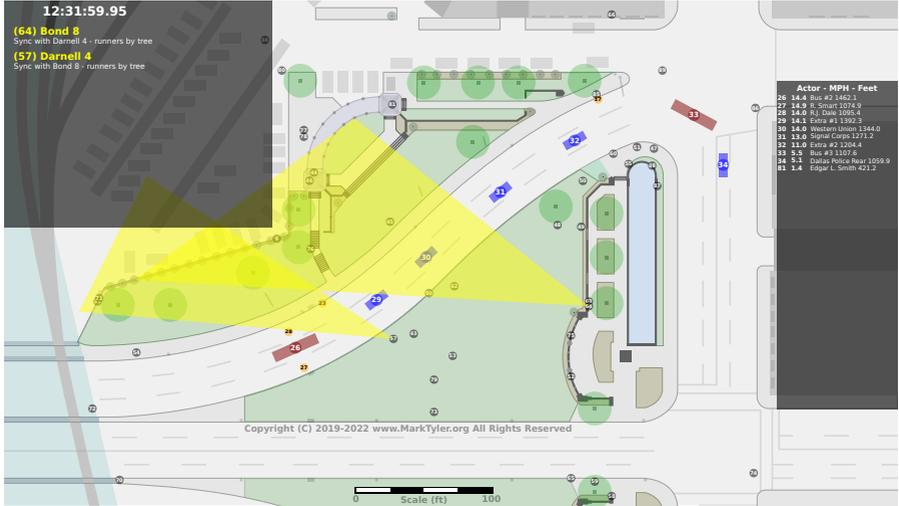
Harry Cabluck took a photo about a minute and a half after the shooting stopped, catching C.A. Haygood in the background. This frame has an overlay of the route Robert MacNeil took up the grassy knoll. Cabluck 2 syncs with Jimmy Darnell filming MacNeil running and William Newman thumping the ground.

Figure 48: Darnell Film Frame & Photo “Cabluck 2”



E.16 Bond 8

Figure 49: Animation Frame “Bond 8”



The Bond 8 photo was taken nearly two minutes after the assassination had finished. At the same time, Jimmy Darnell was filming the same area of the grassy knoll, hence the yellow triangles are overlapping (note the person in the light jacket running, with their shadow reaching the tree).

Figure 50: Darnell Film Frame & Photo “Bond 8”



F Dealey Plaza Witness Survey

With so many contradictions and discrepancies in this case, an exhaustive witness survey is a useful guide for evaluating the many theories that have been concocted over the years. Several witness studies have been published which I have found very useful for creating my own survey:

- John McAdams²²⁴
- Josiah Thompson²²⁵
- Mike Russ²²⁶
- Pat Speer²²⁷
- Stewart Galanor²²⁸
- Todd Wayne Vaughan²²⁹

After reading all of the witness statements and interviews that I could find I summarised the information in a spreadsheet. I was able to determine several things regarding the number of shots fired and when they were fired. This spreadsheet can be downloaded by anyone who wants to check my work²³⁰.

The method I have used for measuring shots is as follows:

- If a witness gave a single number for total shots fired I use that. If a minimum and maximum is given, an average is calculated.

²²⁴<https://www.jfk-assassination.net/shots.htm>

²²⁵“*Six Seconds In Dallas*” appendix A, p.252 <https://archive.org/details/SixSecondsInDallas>

²²⁶<https://www.jfk-assassination.net/russ/wit.htm>

²²⁷Chapters 5-9 <https://www.patspeer.com/chapter5thejigsawpuzzle>

²²⁸<https://www.history-matters.com/analysis/witness/index.htm>

²²⁹<http://jfk.hood.edu/Collection/Weisberg%20Subject%20Index%20Files/M%20Disk/Motorcade%20Route/Item%2015.pdf>

²³⁰https://www.marktyler.org/mc63/mc63_dpws.csv

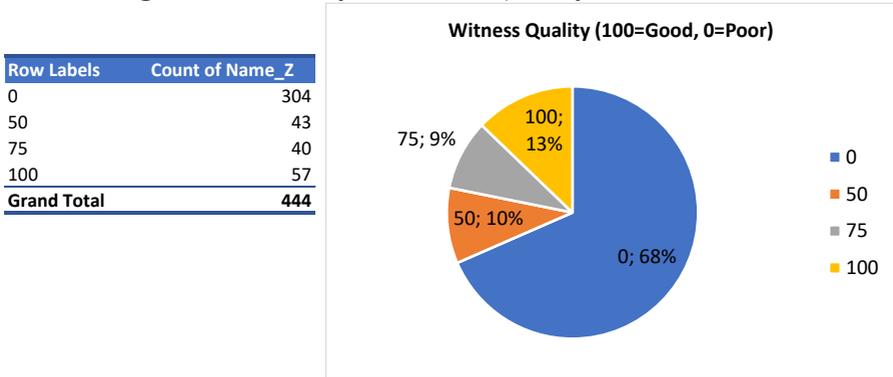
- I have judged the shot sequences that the witnesses reported by splitting the timeline into three periods of time associated with the bursts of noise that the witnesses most commonly mentioned:
 - Around or before time Z240.
 - Around the time Z270-Z330.
 - Around or after time Z360.
- I have made a judgement regarding witness quality as follows:
 - Can the witness associate the first and last shots with a clear point in time, such as an event or a position of the cars in the motorcade? If so I note them in the spreadsheet as high quality due to the extra detail they have given.
 - If the witness first made a public statement long after the assassination (e.g. 1978), I mark their reliability downwards as their memory may have been influenced by the various published theories.
 - Does the film and photographic record support or challenge the witness statement? Any challenges will reduce the quality noted in the spreadsheet.
 - Is a witness statement clear or is it ambiguous? Ambiguity forces me to reduce the quality rating of a witness.
 - To express uncertainty about whether 0, 1, or more shots were reported in a particular burst I have used 0.5 to mean 0 or 1 shots in a burst; 1.5 to mean 1 or 2 shots in a burst; etc. In the following pie charts this is a useful way to judge the margin for error in terms of the results.

F.1 Witness Quality

Using my criteria for witness quality, the spreadsheet calculates a percentage based on the quality of the first burst position and the last burst time position (I say a witness is reliable if they score 75%

or higher here). For more detail regarding how I assess reliability see appendix F.9. The overall witness totals in each quality group are as follows:

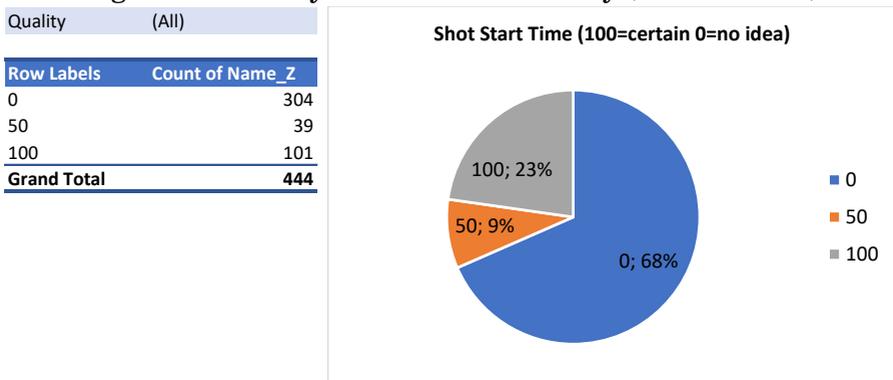
Figure 51: Survey: Witness Quality (all witnesses)



F.2 Witness Certainty

Here is a graph showing how many witnesses gave measurable information regarding the time when the shooting started:

Figure 52: Survey: First Shot Certainty (all witnesses)

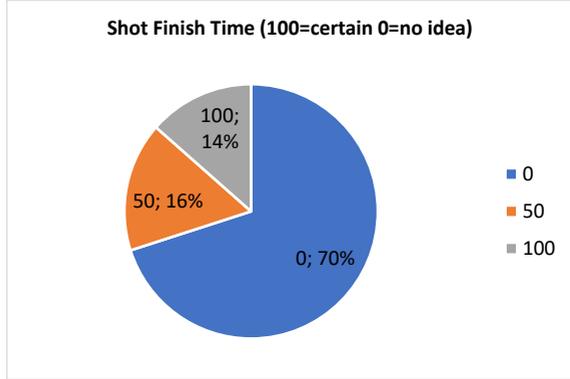


Here is a graph showing how many witnesses gave measurable in-

formation regarding the time when the shooting stopped:

Figure 53: Survey: Last Shot Certainty (all witnesses)

Quality	(All)
Row Labels	Count of Name_Z
0	311
50	73
100	60
Grand Total	444

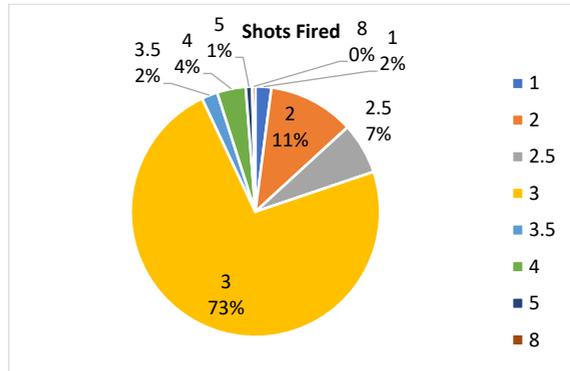


F.3 Shots Fired

Here is the graph showing the number of shots that witnesses think were fired:

Figure 54: Survey: Shots Fired (all relevant witnesses)

Quality	(All)
Row Labels	Count of Name_Z
1	5
2	27
2.5	16
3	177
3.5	5
4	9
5	2
8	1
Grand Total	242

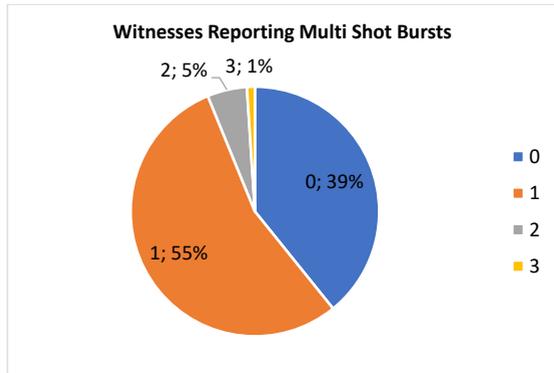


F.4 Bunched Shots

Some witnesses reported bunched shots, but others reported evenly spaced shots. Here are the number of bunched shot bursts that the most reliable witnesses heard:

Figure 55: Survey: Bunched Shot Bursts (reliable witnesses)

Quality	(Multiple Items)
Row Labels	Count of Name_Z
0	38
1	53
2	5
3	1
Grand Total	97

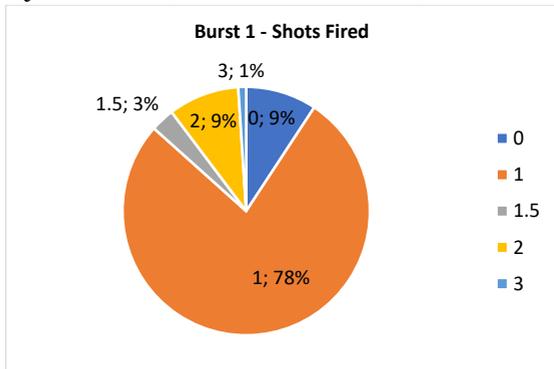


F.5 Shot Burst 1

A large majority of witnesses think there was just a single shot fired during “Burst 1”:

Figure 56: Survey: Burst 1 (reliable witnesses)

Quality	(Multiple Items)
Row Labels	Count of Name_Z
0	9
1	75
1.5	3
2	9
3	1
Grand Total	97

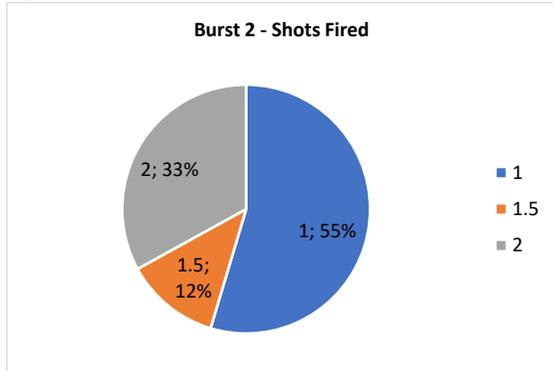


F.6 Shot Burst 2

Most witnesses think a single shot was fired in “Burst 2”, but there is a sizeable minority who think two shots were fired:

Figure 57: Survey: Burst 2 (reliable witnesses)

Quality	(Multiple Items)
Row Labels	Count of Name_Z
1	53
1.5	12
2	32
Grand Total	97

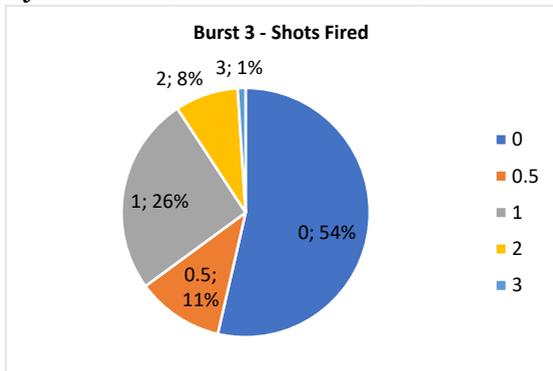


F.7 Shot Burst 3

The witnesses are extremely split on what happened at the end of the assassination in “Burst 3”:

Figure 58: Survey: Burst 3 (reliable witnesses)

Quality	(Multiple Items)
Row Labels	Count of Name_Z
0	52
0.5	11
1	25
2	8
3	1
Grand Total	97



F.8 Shot Permutations

We can study the permutations of all shots reported in each burst via a pivot table, and sort the results by their frequency:

Figure 59: Survey: Shot Permutations (reliable witnesses)

Quality		(Multiple Items)				
B1	B2	B3	Count of Name_Z	Count of Name_ZZ		
	1	1	1	20	20.62%	
	1	1	0	15	15.46%	
	1	1	2	1	1.03%	
	1	1	0.5	1	1.03%	
	1	2	0	28	28.87%	
	1	2	1	1	1.03%	
	1	1.5	0.5	9	9.28%	
	0	1	2	6	6.19%	
	0	1	1	2	2.06%	
	0	2	0.5	1	1.03%	
	2	1	0	5	5.15%	
	2	1	1	2	2.06%	
	2	1	2	1	1.03%	
	2	2	0	1	1.03%	
	1.5	1.5	0	3	3.09%	
	3	2	3	1	1.03%	
Grand Total				97	100.00%	

Each column has been sorted in descending order and we see that the two most commonly reported patterns are “111” and “120”, which both total three shots each. The third most commonly reported pattern is “110” but this contradicts the total of three shots that most witnesses reported.

F.9 Witness Reliability

Collectively the witness reports are contradictory, such as different people reporting two, three, or four shots. They can't all be right so we need to have a way of parsing and understanding what the witnesses tell us without rejecting potentially useful information. The witness survey allows us to quantify the witness statements, but we must also study the quality of the statements as this may reveal crucial details that would otherwise be missed using just data analysis tools.

F.9.1 Suggestibility

Perhaps the most troubling aspect of witness testimony is where a witness gave one statement in 1963, and then a few years later tell a very different story, maybe due to suggestibility²³¹. For example Jean Hill was asked on the day of the assassination:

“Did you see the person who fired the shot?”²³²

Her reply was:

“No I didn't see any person fire the weapon—I only heard it. I looked up and saw this person running up this hill.”

The person she is probably referring to is visible in figure 60, which shows Hill in the red coat in the foreground, with the man on the other side of the road on the steps, commencing his dash up the hill:

²³¹<https://en.wikipedia.org/wiki/Suggestibility>

²³²NBC News 1963-11-22 <https://youtu.be/oJnoFA0u2Eg?t=8834>

Figure 60: Film Frame “Muchmore 591”



29 years later in 1992 Hill said:

“It was right up there, the man was shooting from right just this side of that tree, that large tree. That’s where I saw the shot come from.”

“I definitely saw the man shooting from the knoll.”²³³

The tree she was referring to was just behind the concrete wall where others had placed the so called “Badge Man”²³⁴ figure in the Moorman photo taken at the moment of the fatal shot. This interview took place some years after Badge Man was first publicly discussed. Since this interview was recorded in 1992, the Badge Man figure has been proven not to be human due to its small size relative to the people on the steps, and the size of Abraham Zapruder on the nearby pedestal.

In this case I have favoured the earlier statement as I conclude that if a witness gave a full account on the day, their memory will be fresher and less tainted by other statements made in the media.

²³³“Beyond JFK: The Question of Conspiracy” (1992) 9:10 & 12:55 <https://archive.org/details/BeyondJfkAQuestionOfConspiracy>

²³⁴https://en.wikipedia.org/wiki/Badge_Man

Hill mentioning puffs of smoke in 1992 seems awfully like some of the other witnesses statements which became heavily cited in books and the media from 1964 onwards, so I ignore these comments as they weren't mentioned by Hill in 1963 and 1964 in her very lucid interviews.

Some witnesses changed their minds even more quickly, and gave a different account of events just days after the assassination. For example William Newman said this in a TV interview on the afternoon of the assassination:

*"I don't recall a third shot—there may have been—my family hit the ground, and I don't recall a third shot. I do know I heard two shots."*²³⁵

However, just 48 hours later an FBI statement quoted him from an interview:

*"He said the President was hit on the right side of the head with the third shot"*²³⁶

As the earliest statement was so clear, I tend to favour that as the most accurate recollection that Newman has given regarding what he heard. During the TV interview Newman was repeatedly told there was a third shot, and with other people (including his wife Gayle) mentioning more shots, his memory may have been influenced by other comments about the number of shots fired.

F.9.2 Attentiveness

Human beings are not mechanical recording devices and their senses can only be of use when focused. If a persons attention is elsewhere they will not be able to perceive and remember as well as someone who is paying more attention.

²³⁵WFAA-TV interview 1963-11-22 <https://youtu.be/iC1ebqkXGTk?t=699>

²³⁶1963-11-24 22H843 https://www.history-matters.com/archive/jfk/wc/wcvols/wh22/html/WH_Vol22_0437a.htm

For example James Altgens said:

*“There was not another shot fired after the President was struck in the head. That was the last shot—that much I will say with a great degree of certainty.”*²³⁷

Malcolm Summers was standing near Altgens during the shooting, and confirmed this by saying:

*“The President’s car had just come up in front of me when I heard a shot and saw the President slump down in the car and heard Mrs Kennedy say ‘Oh, no’, then a second shot and then I hit the ground as I realized these were shots.”*²³⁸

In the Zapruder film we see Summers hit the ground after the fatal head shot which suggests he didn’t hear any more shots after this point.

By contrast several other witnesses disagree and are certain that another shot was fired. Therefore I need to explain this conflict somehow, such as:

1. Altgens and others are wrong as there was a shot fired after the fatal head shot.
2. Altgens and others are right as there was not a shot fired after the fatal head shot.

In this instance I favour explanation 1 due to the synchronizations in the animation and the supporting eyewitness testimony. It’s more likely that a few people are independently mistaken due to being distracted rather than a dozen being wrong when describing the same event happening at the same time (i.e. a shot being fired circa Z400).

²³⁷WCR V.7 p.518 https://history-matters.com/archive/jfk/wc/wcvols/wh7/html/WC_Vol7_0263b.htm

²³⁸WCR V.9 p.500 Sheriff statement 1963-11-23 https://www.history-matters.com/archive/jfk/wc/wcvols/wh19/html/WH_Vol19_0259b.htm

It should also be borne in mind that Altgens was taking a photo around Z400 so his attention would have been focused on that, rather than any of the other distractions happening in that moment (e.g. crowd screaming, vehicle noise, shot, etc). In particular for Altgens and Summers a noisy Harley Davidson bike ridden by B.J. Martin was passing them around the time of the third shot which would have caused them to be more distracted than other people. Perhaps even louder than this was the siren that was sounding just before the final shot was fired (as explained in section 6.1.1), which was located just 10-15 feet in front of Altgens and Summers and probably masked the noise of the final gunshot.

F.9.3 Equivalence

Many witnesses described hearing three shots. However, this does not necessarily mean they heard the same three shots. Mary Moorman said:

*“I snapped the picture, and at the same time I snapped the picture I heard a sound. Then I had my picture taken, and was not holding the camera in front of my face and I heard two more sounds.”*²³⁹

Please note the difference from what James Altgens said in section F.9.2, as he described the head shot as the second shot. Therefore when we say most witnesses heard the same number of shots we must make an effort to identify which shots in the sequence they are referring to.

In this specific case Moorman heard two shots after the fatal shot, but Altgens heard none. Also, Altgens heard one shot before the fatal shot whereas Moorman heard none. Ergo between both witnesses they collectively heard four separate shots, even though neither of them claimed to hear all four. This is important because other witnesses on the underpass bridge did hear four shots.

²³⁹IAntique.com interview 2011-05-24 <https://youtu.be/WgNF-sPW8YI?t=>

Not hearing the first shot that hit JFK, and still hearing three or more shots is not unique to Moorman. On the same side of Elm Street and just to the west of Altgens were Jack Franzen and his family. Mr Franzen gave evidence to the FBI two days after the assassination, who then reported:

*“He said he heard the sound of an explosion which appeared to him to come from the President’s car and noticed small fragments flying inside the car and immediately assumed someone had tossed a firecracker inside the automobile. He heard a second and third and possibly a fourth explosion and recognized these sounds as being shots fired from some firearm.”*²⁴⁰

Mrs Franzen gave evidence to the FBI three days after the assassination, who then reported:

“She advised shortly after the President’s automobile passed by on Elm Street near where she and her family were standing, she heard a noise which sounded to her as if someone had thrown a firecracker into the President’s automobile. She advised at approximately the same time she noticed dust or small pieces of debris flying from the President’s automobile.

*She advised she heard two other sounds which sounded like shots from a firearm and noticed blood appearing on the side of President Kennedy’s head.”*²⁴¹

Ruby Henderson also mentioned at least one shot after the fatal shot, possibly three, depending on whether she missed the the first like Mr & Mrs Franzen. She is quoted in an FBI interview from 1963-12-06:

“Mrs Henderson said at the time the motorcade passed where she was standing, she heard what she initially thought was a firecracker and saw what she thought was paper fly out of the Presidential car.

²⁴⁰WCR CE 1428 https://www.history-matters.com/archive/jfk/wc/wcvols/wh22/pdf/WH22_CE_1428.pdf

²⁴¹WCR CE 2090 https://www.history-matters.com/archive/jfk/wc/wcvols/wh24/html/WH_Vol24_0272a.htm

*She said she now realized it was a shot she heard and what she thought was paper was probably flesh. She said after the first shot, she believes she heard two more in rapid succession, and then a fourth shot.*²⁴²

If Moorman, Henderson, and the Franzen's did indeed hear two shots fired after the fatal head shot then at least four shots were fired in total.

F.9.4 Weight

When evaluating witness evidence it's important to consider the weight of the evidence provided by the witnesses. I consider "weight" here to mean primarily the quality of the witness account (e.g. how much detail they offer in their early statements), not merely the quantity of other witnesses who agree. Conversely many researchers erroneously assume that if dozens of witnesses say something then it must be believed regardless of the basis in fact.

With so much contradictory evidence in this case I think the best approach is to study the evidence, and weigh up each of the possibilities to decide upon each of the conflicts as they appear. For example the witnesses mostly say that three shots were fired. However, as shown in section F.8, the witnesses are split regarding the pattern of these shots (some said the shots were evenly spaced, whereas others said that they were bunched). There is no simple explanation of all of those conflicts, but it's fair to assume that many witnesses were simply mistaken in their views (possibly due to the stress of the situation).

²⁴²WCR CE 2089 https://www.history-matters.com/archive/jfk/wc/wcvols/wh24/html/WH_Vol24_0271b.htm

F.9.5 Time

Many witnesses gave their estimation of time between shots, which ranged from 1 to 5 seconds typically. Witnesses also gave a total time for all the shots to be fired, which ranged from 4 to 10 seconds typically. For example Phil Willis said there were 2 seconds between the three shots he heard²⁴³ and Malcolm Couch said the whole shooting lasted 10 seconds²⁴⁴. When considering these time estimates it's important not to be too pedantic as these are merely human impressions rather than precise measurements. A good illustration of this regards two photos that Phil Willis took, known as "Willis 4" and "Willis 5". According to Mc63 the time between the two was 3.8 seconds (Z133 to Z202 at 18.3 FPS). This is what Willis said about that time gap:

*"not more than 3 seconds."*²⁴⁵

This means he was almost correct, but he slightly underestimated the real time somewhat. Most witnesses seem to cluster into two groups regarding total shot duration:

- 4-6 seconds.
- 8-10 seconds.

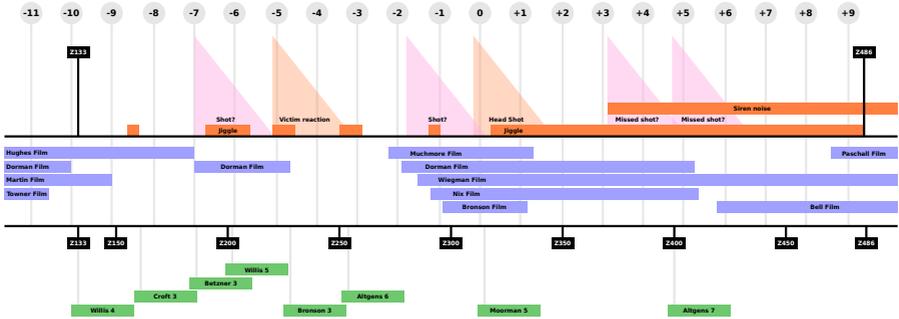
This suggests to me that those who report 4-6 seconds missed either the first or the last burst of noise (which was fairly common judging from the survey). An easier way to understand this is to view a timeline of assassination events:

²⁴³WCR V.7 p.495 https://www.history-matters.com/archive/jfk/wc/wcvols/wh7/pdf/WH7_PhillipWillis.pdf

²⁴⁴FBI interview 1963-11-27 WCR CD5 https://www.history-matters.com/analysis/witness/witnessMap/documents/wcd_hsca/wcd_hsca_0045a.gif

²⁴⁵WCR V.7 p.494 https://www.history-matters.com/archive/jfk/wc/wcvols/wh7/pdf/WH7_PhillipWillis.pdf

Figure 61: Assassination Timeline



The light orange triangles represent the known shot events in the Zapruder film. The light pink triangles represent times where there is some evidence of shots being fired, such as witness statements or jiggling in the Zapruder film. With no evidence of these extra shots hitting the victims, either they were missed shots (possibly decoys) or they did not happen and the witnesses were simply wrong. If there were two gunmen they each had about 5 seconds to reload and aim between shots.

The timeline enables us to see some interesting patterns regarding the films and when they were stopped relative to the Zapruder film:

- The Dorman film seems to be stopped about the same time we see JFK and John Connally reacting to being shot in the Zapruder film (Z225-Z240).
- The Muchmore and Bronson films were both stopped within a fraction of a second of each other about 1.5 seconds after the fatal head shot.
- The Nix and Dorman films were both stopped within a fraction of a second of each other about 0.5 to 2 seconds after the last shot.

These events are consistent with the camera operators being startled by noisy gunfire and deciding to stop filming. Studying the witness interviews and statements help us understand these events a

little more. In 1998 Gary Mack mentioned that Elsie Dorman said she stopped filming after the first shot:

*“She remembered that the first shot was very loud and sounded like it came from behind her. She said she stopped filming just after the first shot, but it’s hard to tell exactly when that moment occurs in the film.”*²⁴⁶

This is similar to what she said in 1963 and 1964, but sadly no more concrete details were given:

*“I was at this window attempting to photograph the motorcade when I heard a noise like gunshots.”*²⁴⁷

*“The window was raised and she was taking pictures. It was at this time she heard sounds which sounded like shots. She felt that these shots were coming from the area of the Records Building.”*²⁴⁸

Then we have Orville Nix who spoke to the FBI in the days following the assassination:

*“Nix then moved west on Main Street and the film picks up the motorcade subsequent to the firing of the first two shots. Nix believed the film depicts the third shot hitting President Kennedy and the sequence of events immediately after including Mrs Jacqueline Kennedy reaching out over the back trunk lid to assist a Secret Service agent who is running to her aid.”*²⁴⁹

This indicates that he heard two shots before Z280-Z291 when he started recording that section of his film. Sadly he didn’t give any more details in other interviews or statements, but we can deduce

²⁴⁶<https://groups.google.com/forum/#!msg/alt.assassination.jfk/2IuxOMrJZzU/eFc-1lWs8mAJ>

²⁴⁷Statement 1964-03-20 WCR V.22 p.644 https://www.history-matters.com/archive/jfk/wc/wcvols/wh22/html/WH_Vol122_0337b.htm

²⁴⁸FBI report 1963-11-23 WCR CD5 https://www.history-matters.com/analysis/witness/witnessMap/documents/wcd_hsca/wcd_hsca_0053a.gif

²⁴⁹FBI interview 1963-12-01 WCR V.24 p.539 https://www.history-matters.com/archive/jfk/wc/wcvols/wh24/html/WH_Vol24_0279a.htm

that he is probably referring to shots fired at Z185 and Z220 as per the other witness statements.

G References

Unless otherwise stated, the sources I used for photos, films, and documentation are listed in this appendix.

G.1 Photos

- JFK Assassination Gallery²⁵⁰
- Sixth Floor Museum²⁵¹

G.2 Films

- AMIPA²⁵²
- Atkins²⁵³
- Bell^{254 255}
- Bronson²⁵⁶
- Couch^{257 258}
- Daniel²⁵⁹

²⁵⁰<https://www.jfkassassinationgallery.com>

²⁵¹<https://emuseum.jfk.org/objects/images>

²⁵²John Robert Yeargan collection <https://www.youtube.com/watch?v=aWAAqnv7XAQ>

²⁵³*“The Last Two Days”* <https://www.jfklibrary.org/asset-viewer/archives/JFKWHF/WHN17/JFKWHF-WHN17/JFKWHF-WHN17>

²⁵⁴<https://www.youtube.com/watch?v=AhmeQicc6YE>

²⁵⁵<https://www.youtube.com/watch?v=WyCtms-UE0o>

²⁵⁶<https://emuseum.jfk.org/objects/47373/charles-l-bronson-film>

²⁵⁷<https://www.youtube.com/watch?v=zmexsNkEiHc>

²⁵⁸<https://www.youtube.com/watch?v=o4GGU6-n1BM>

²⁵⁹<https://www.dailymotion.com/video/xeszxy>

- Darnell^{260 261}
- Dorman²⁶²
- Hughes²⁶³
- Martin²⁶⁴
- Muchmore^{265 266}
- Nix^{267 268}
- Paschall²⁶⁹
- Towner²⁷⁰
- Wiegman²⁷¹
- Zapruder^{272 273 274}

G.3 Website Links

Here is a list of the most useful websites that I used as sources in the first five months of the project (alpha order):

²⁶⁰<https://www.youtube.com/watch?v=PCHTdTF7YbE>

²⁶¹<https://www.dailymotion.com/video/x6tx3l3>

²⁶²<https://emuseum.jfk.org/objects/11267/elsie-dorman-film>

²⁶³<https://emuseum.jfk.org/objects/23202/robert-hughes-film>

²⁶⁴<https://www.youtube.com/watch?v=KqMtbNBxIYU>

²⁶⁵<http://www.aparchive.com/compilationsclipreel/41804/19617/>

People

²⁶⁶<https://youtu.be/sMdreKlLhJY>

²⁶⁷<https://emuseum.jfk.org/objects/32262/orville-nix-film>

²⁶⁸https://youtu.be/ydQtC0m_xzc

²⁶⁹<https://www.youtube.com/watch?v=kiddBtPpdEM>

²⁷⁰<https://emuseum.jfk.org/objects/43384/tina-towner-film>

²⁷¹<https://youtu.be/M4mUvR3WToU?t=7850>

²⁷²<https://emuseum.jfk.org/objects/32274/abraham-zapruder-film>

²⁷³<https://www.assassinationresearch.com/zfilm>

²⁷⁴<https://sites.google.com/site/lightboxzframes/>

- JFK Assassination Gallery²⁷⁵ (Robin Unger)
- JFK Lancer²⁷⁶
- JFK Library²⁷⁷
- Mary Ferrell Foundation²⁷⁸
- National Archives²⁷⁹
- Pat Speer²⁸⁰
- The Sixth Floor Museum²⁸¹
- The Weisberg Collection, Hood College²⁸²

While developing this document I also used these sources when pursuing lines of enquiry:

- alt.assassination.jfk^{283 284}
- Dale K. Myers^{285 286}
- David Von Pein²⁸⁷

²⁷⁵<https://www.jfkassassinationgallery.com>

²⁷⁶<http://www.jfklancer.com>

²⁷⁷<https://www.jfklibrary.org>

²⁷⁸<https://www.maryferrell.org>

²⁷⁹<https://www.archives.gov/research/jfk>

²⁸⁰<http://www.patspeer.com>

²⁸¹<https://www.jfk.org>

²⁸²<http://jfk.hood.edu>

²⁸³<https://groups.google.com/forum/#!forum/alt.assassination.jfk>

²⁸⁴Mc63 thread https://groups.google.com/forum/#!topic/alt.assassination.jfk/o_tGsuLelTI

²⁸⁵<https://www.jfkfiles.com>

²⁸⁶<http://jfkfiles.blogspot.com>

²⁸⁷<http://davidvonpein.blogspot.com>

- Education Forum^{288 289 290}
- History Matters²⁹¹ (Rex Bradford)
- JFK Assassination Forum^{292 293}
- John McAdams²⁹⁴
- John T. Orr²⁹⁵
- Max Holland²⁹⁶
- Prayer Man²⁹⁷ (Bart Kamp)
- The Puzzle Palace²⁹⁸ (Anthony Marsh)

G.4 Warren Commission

- AARC²⁹⁹
- History Matters³⁰⁰
- Internet Archive³⁰¹

²⁸⁸<http://educationforum.ipbhost.com/forum/126-jfk-assassination-debate>

²⁸⁹Mc63 thread <http://educationforum.ipbhost.com/topic/25932-the-motorcade-puzzle/>

²⁹⁰DPWS thread <http://educationforum.ipbhost.com/topic/26676-dealey-plaza-witness-survey/>

²⁹¹<https://history-matters.com/jfkmurder.htm>

²⁹²<https://www.jfkassassinationforum.com>

²⁹³Mc63 thread <https://www.jfkassassinationforum.com/index.php/topic,2277.0.html>

²⁹⁴<https://www.jfk-assassination.net/home.htm>

²⁹⁵<http://www.mountainrivercabins.com/JFK>

²⁹⁶<https://www.washingtondecoded.com>

²⁹⁷<http://www.prayer-man.com>

²⁹⁸<http://www.the-puzzle-palace.com>

²⁹⁹https://aarclibrary.org/publib/contents/contents_wc.htm

³⁰⁰<https://history-matters.com/archive/jfk/wc/contents.htm>

³⁰¹<https://archive.org/details/WarrenReport>

- Mary Ferrell Foundation³⁰²
- National Archives³⁰³
- Wikipedia³⁰⁴

G.5 HSCA

- AARC³⁰⁵
- History Matters³⁰⁶
- Internet Archive³⁰⁷
- Mary Ferrell Foundation³⁰⁸
- National Archives³⁰⁹
- Wikipedia³¹⁰

G.6 Feedback Credit

After I originally published the animation in 2019 several people have helped me make the work better by: reporting errors; challenging my assumptions; making useful suggestions; giving me an opportunity to network with a wider group of people. I am very grateful for these contributions, even when I am proven to be wrong

³⁰²https://www.maryferrell.org/pages/Warren_Commission.html

³⁰³<https://www.archives.gov/research/jfk/warren-commission-report>

³⁰⁴https://en.wikipedia.org/wiki/Warren_Commission

³⁰⁵https://aarclibrary.org/publib/contents/contents_hsca.htm

³⁰⁶<https://history-matters.com/archive/jfk/hsca/contents.htm>

³⁰⁷https://archive.org/details/HSCA_Report

³⁰⁸<https://www.maryferrell.org/pages/HSCA.html>

³⁰⁹<https://www.archives.gov/research/jfk/select-committee-report>

³¹⁰https://en.wikipedia.org/wiki/United_States_House_Select_Committee_on_Assassinations

or they disagree with my work! Here is a list of these people who are known publicly on the web in the research community:

Pat Speer, John Butler, Chris Davidson, David Josephs, Robin Unger, Margaret Kelly, Michael Walton, Anthony Marsh, Max Holland, Nick Nalli, Paul Hoch, Randy Robertson, Jeff Morley, Mike Russ, Larry Schnapf, John Orr, Jerry Policoff, Ramon Herrera, Randy Owen, Todd Vaughan, Jerry Organ, Tony Krome, John McAdams, Dale Myers.

Others have contacted me on a private or anonymous basis, and I am very grateful for these contributions also.

Part V

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$$\int_{88}^{19} \Sigma dx \approx \text{Mc}^{63}$$

